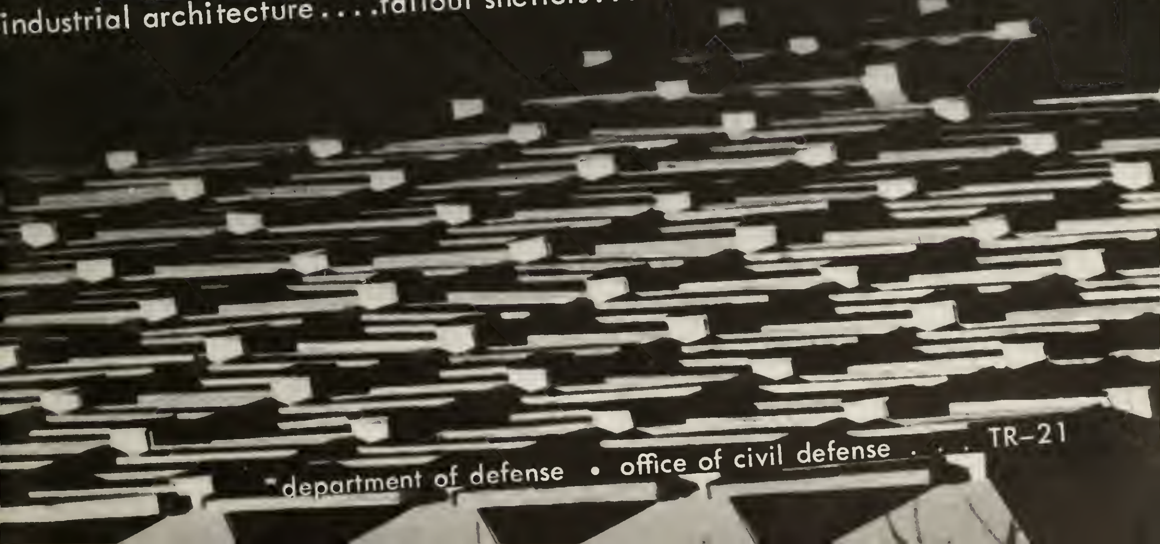
industrial architecture....fallout shelters....



department of defense • office of civil defense . . . TR-21

a research project by the department of architecture, rice university, houston, texas
conducted under contract with the department of defense, office of civil defense, washington d.c. 20301

Nov. 1963

As a part of the Defense Department's program to provide shelter from radioactive fallout in the event of a nuclear attack, the Office of Civil Defense conducted the National Shelter Survey. As a result, over 108 million shelter spaces were found throughout the country. The total needs of the Nation are 240 million spaces. The difference must be met largely through the creation of shelter in new construction as the country builds and by the improvement of existing structures possessing good shelter potential. This will be done over the next few years on the initiation of both public and private organizations working together to meet local requirements.

This brochure illustrates five ways of obtaining dual-use shelter space without affecting function or esthetics, and at small additional cost. The subject selected - the industrial building - is one of the most important in our economy.

The designs show conclusively that efficient, attractive industrial buildings can be designed to include protection from the effects of fallout gamma radiation if considered in the initial design stages. Each solution provides shelter unobtrusively in a pleasant environment. This can be done not only in industrial buildings but in other types as well.

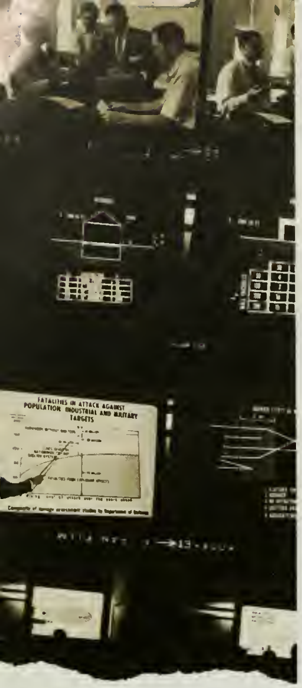
American industry has always met the challenge of changing times. Now, in the nuclear age, it is more important than ever to sustain this tradition.

The five architects, their teams, and the Staff of the Rice University Department of Architecture are congratulated for the results of their imaginative and creative skills applied to a vital problem in our overall defense effort.

STEUART L. PITTMAN
Assistant Secretary of Defense for Civil Defense

[redacted]

Five prominent architects were invited to participate on the campus of Rice University, June 3 through 14, 1963. Five separate industrial problems were defined - manufacturing plants, each in a different section of the country, each reflecting a different process, but with one common aspect, the inclusion of a fallout shelter to provide protection for a minimum of twice the total number of daytime employees of the plant. Each architect was assigned one of the problems and a team of six students. Consultants from the Office of Civil Defense, a qualified fallout shelter analyst, a climatologist, structural and mechanical consultants, and industrial management specialists were available. A limit of ten working days was set for the solution of the problems, with an oral and graphic presentation on the tenth day. The architects and students lived and worked together on the Rice University campus. The value to the Office of Civil Defense was the creative and imaginative solutions for a very real problem for dual-use space for fallout shelters. The value to each student was experiencing a work situation with a successful architect and helping the architect in the solution of a difficult design problem. The value to each architect was experiencing a new office routine by working in an academic setting, exchanging ideas with special consultants, other architects, and the students, and serving as a coordinator and an example for his student team.



INTRODUCTION INDUSTRIAL ARCHITECTURE

This publication is a result of a research contract awarded to Rice University, Department of Architecture, Houston, Texas, to conduct an architectural design conference to solve specific design problems and also to determine the effectiveness of this technique in research. The building type chosen as the research subject was the industrial plant - with dual-use space for inclusion of community fallout shelter. The purpose was to focus attention on a building type that is important to the Nation both in terms of the people and the process which it houses. The intent in bringing five experienced industrial architects, fallout shelter and engineering consultants, and 30 advanced architectural students together on campus for an intensive design session was to provide insight into the problem of incorporating fallout protection in industrial buildings. The resulting solutions by the five different architects show how factories designed in accord with realistic industrial programs are able to meet the needs of the clients and at the same time provide fallout shelters in dual-use space at minimal added cost to the total project. Studies of the designs showed further that the inclusion of shelter increased the cost by $.08 to $.48 per square foot of plant area. When pro-rating the total shelter cost over the area of the shelter only, the additional cost per square foot varied from $.77 to $4.33 with the average just under $2.50. These costs are tabulated for each plant on pages 54 and 55.

Our Government's policies are directed toward making nuclear war as unlikely as possible, but there can never be total assurance that we will not be attacked. Should nuclear war come, the existence of this Nation will depend on the ability to protect as much of the population as possible from injury and death. Our ability to survive and recover will depend largely on the ability of industry to survive and resume operation. That is why industry was chosen as the subject of this case study. It represents one of the most important segments of our economy, and the story of the progress of this nation has been the story of industrial progress. Today industry employs the majority of the working force and accounts for a current annual expenditure of $38 billion in new plant construction and equipment. The development of industry in a competitive system of free enterprise has always been marked by the ability of responsible and imaginative leaders to accept and adapt innovations in production methods in their constant search for better ways to produce better products at competitive prices. Often this has meant a concern for better facilities to house the manufacturing process or to improve the conditions of the workers and the executives.

In its National Shelter Program, the Office of Civil Defense, Department of Defense, has the goal of creating shelter from fallout gamma radiation for every person in the country. To meet this need, new buildings must contain enough shelter to supplement more than a hundred million shelter spaces already found in existing buildings through a nationwide survey by the Office of Civil Defense. The architects and engineers who design our structures must know how to plan for this requirement, which has become an integral element of the country's defense.

As an important part of the full shelter program, the Office of Civil Defense is engaged in several professional development activities for architects and engineers. Among these are: (1) the professional development of architects and engineers in fallout shelter design to evaluate existing buildings and to design shelters in new buildings, (2) operation of short courses for the development of professional knowledge, (3) experimentation with equipment and facilities for shelters, and (4) research by organizations and universities to study problems related to shelter design.

The development of the capability for protective construction among architects and engineers is the responsibility of the Architectural and Engineering Development Division of the Office of Civil Defense, which works directly with the organized professions and the schools of architecture and engineering. Courses are offered to architects and engineers at various schools and universities throughout the country to acquaint them with the new technology of radiation shielding design and analysis. Certification by the Department of Defense as a qualified shelter analyst is granted upon successful completion of the course. Those architects and engineers wishing to enroll in these courses can contact their nearest local, state or regional civil defense office for information and enrollment forms.

The topic of this report deals with both the facilities of the plant and the protection of the occupants from fallout gamma radiation in the event of possible nuclear attack. By creating this protection, responsible leaders of industry will provide this security as an extra employee benefit and also contribute to the strength and preparedness of the country. It is the architect's role both to advise the building owner and to translate his industrial program into physical reality. The architect's honest expression of the functions of various manufacturing processes produces an architecture of bold forms, clarity of structure, and integrity of materials which has become the credo of contemporary architecture. As needs become more complex, the architect's role becomes even more vital. The industrial building is a trademark for the product, and the plant facilities are the environment which influences the efficiencies, loyalties, and attitudes of the workers.

The value of this report to architecture, industry, and the Nation cannot be assessed immediately, but the following shows how five different minds dealt with different problems - but with a common protection consideration. Here utility, economy and beauty are employed intelligently to industry's credit. Here architecture - man's living, useful, three-dimensional art form - rises to meet the challenge of our industrial, nuclear age.

REQUIREMENTS/FALLOUT SHELTER

Knowledge of the sequence of events following a nuclear attack is necessary to understand the objectives of the Fallout Shelter Program. There are two basic classifications of explosions with reference to the earth's surface - surface bursts and air bursts. The effects of these vary and include, in different degrees, thermal radiation, blast and shock, initial nuclear radiation and residual nuclear radiation. The areas affected by thermal radiation, blast and shock and initial radiation are relatively small compared to those areas that could be affected by residual radiation present in fallout. Protection of the population from fallout radiation is the primary objective of the National Fallout Shelter Program.

Radioactive particles from the bomb materials and debris are by-products of a nuclear explosion. With the air burst, they are carried aloft and generally decay to a harmless level before returning to earth. Some never return. With the ground burst, where the fireball touches the earth, debris is swept up in the mushroom cloud, adding weight to the radioactive matter. This causes it to return to earth much sooner than it would otherwise, thus creating the dangerous radioactive fallout.

Fallout is basically of two types - global and local. Global fallout exists today from test explosions which have carried the fission products into the stratosphere. They are extremely fine and have been swept aloft by high level winds allowing the radioactivity to decay before drifting to earth. Ninety per cent of the radioactive matter formed in an air burst stays aloft either permanently or drifts erratically down to earth. Local fallout from a surface burst starts to settle near ground zero within 15 minutes after detonation. It continues for a period of approximately 12 to 24 hours and usually falls in an irregular pattern, dictated by wind direction, often covering hundreds or thousands of square miles. The lighter particles settle much later and farther away and continue to settle for a longer period of time, but their potency diminishes with time.

Protection from local fallout produced by a surface burst is the pri-

mary concern in the design of shelter, but often the same shelter provides a degree of protection from the thermal radiation and blast produced by both types of explosions.

Gamma radiation is transmitted to people in a shelter from three primary sources: overhead contribution which originates from fallout on the roof of the building; ground contribution which originates from fallout on the ground or any surface below the detector; and skyshine contribution which is gamma radiation scattered, or reflected, by atoms in the air.

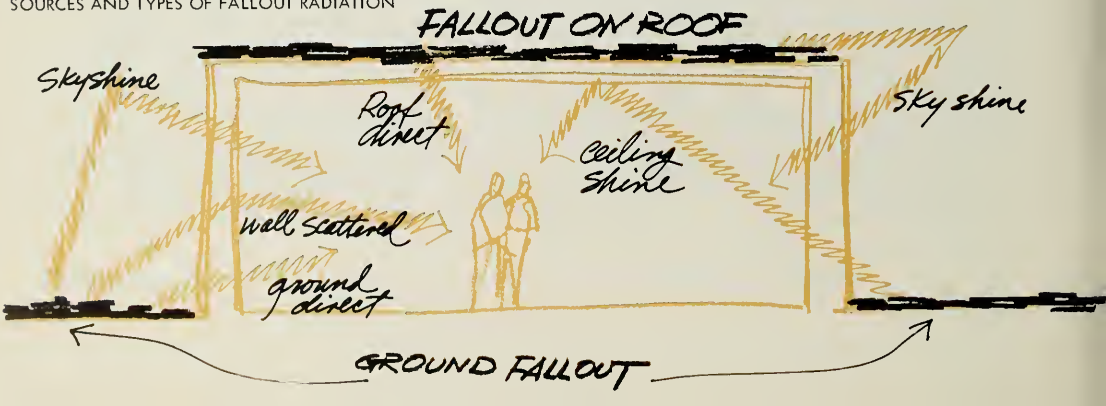
To attenuate radiation, adequate shelter design incorporates geometry and barrier shielding. Geometry shielding places people out of the direct path of radiation or at a distance from it. It is accomplished by designing a building so that the distances from radioactive sources are as great as possible. The effect of gamma radiation is lessened as distance from the source is increased, much the same as light intensity lessens the farther one is from the source.

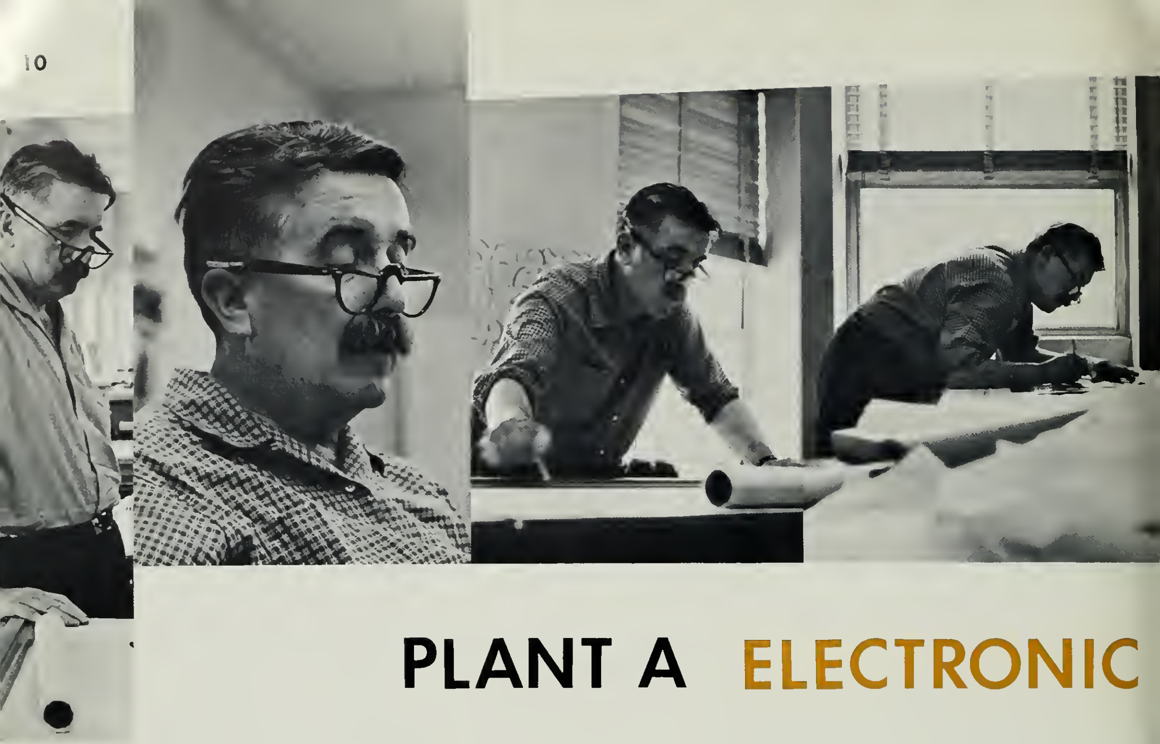
Barrier shielding places mass between the radioactive source and the occupant of the shelter. This reduces the intensity of gamma radiation. Mass may be provided by any normal construction material since the amount of attenuation is determined by the total weight of the material. Twelve inches of concrete (150 lbs./cu. ft.) is approximately equivalent to 48 inches of wood (37 lbs./cu. ft.) for barrier shielding purposes.

In addition to the considerations involved in physical protection, the designer of fallout shelter must be sensitive to human needs. When one must live elbow-to-elbow in a relatively static environment for long periods of time, personal needs become particularly significant. Practical or esthetic, psychological or physiological, the needs are very real and must be considered. Natural human tensions are certain to become acute in a microcosm of human civilization such as the shelter would be.

There are minimum technical requirements established by the Office of Civil Defense, Department of Defense, which provide the basis for economical group community shelters where people can be effectively protected and austerely housed during time of crisis. In the cases in this study, a fallout protection factor of 100 was used. This factor is the ratio of the amount of fallout gamma radiation that would be received by an unprotected person to the amount received by one in a shelter. An unprotected person would be exposed to 100 times more radiation than a person inside a shelter with a protection factor of 100. Another program requirement for the industrial building designs in this report was dual-purpose shelter, having a normal use which would not interfere with its use in emergency. The minimum occupancy required was double the normal number of daytime employees. At least 65 cubic feet of space per person was provided, but not less than ten square feet of shelter floor space each. The designers, in general, were allowed to use any method of design and construction for concrete, wood, steel, brick, structural tile or other conventional building materials capable of satisfying design criteria. Entranceways – at least one access and egress for each 200 inhabitants with a minimum of two means of egress – were to be designed to prevent infiltration of radiation. General provisions had to be made for storage of basic shelter supplies, at least one and one-half cubic feet per person for such items as sanitary kits, medical kits, radiological detection kits, food, and a minimum of three and one-half gallons of water.

SOURCES AND TYPES OF FALLOUT RADIATION





PLANT A ELECTRONIC

INDUSTRIAL PROGRAM

Product: electronic devices for nuclear detection / Process: job lot, individual orders, special engineering, machining, component preparation, sub-assembly, assembly, testing, packing / Required Facilities: administration, reception, purchasing & material control, engineering laboratory, general office, sales, accounting, private office, conference room, cafeteria, recreation room, machine shop, production area, storage, laboratory, locker-restrooms, testing area, special test chamber for radiation source / Employees: 100, two-thirds male, highly technical, future growth to 200 / Site: ten acres, relatively level, utilities from main road, zoned 40% open site, suburban Boston.

ARCHITECTURAL SOLUTION

Russell's philosophy of industrial design is distilled from many years of experience in this field. His design for Plant A is an embodiment of his observations. In his own words, "I am terribly bored with esoteric architecture applied to industry. It seems out of place to me — all the folded plates, barrel vaults and the interest in monumentality and drama instead of liveability. Drama belongs in the theater, not in a factory. It seems to me that it is much more important to have a reasonable structural system, instead of one that is exciting today and boring in five years...to have a modular plan that allows change, growth, and flexibility...to have pleasant surroundings with an abundance of careful landscaping that changes with everchanging patterns of shade and light. If these things are done, the working day will be a pleasant and satisfying one for the worker and better work will be done. The architect's primary job is to bring order from chaos and add a little art in the doing. I hope my plant is unpretentious, efficient and unmonumental."

Translating these precepts into a solution for his plant, Russell proceeds to design the building as a workable tool for the production of nuclear detection devices and as an attractive asset to the community.

George Vernon Russell

George Vernon Russell, FAIA, experienced and articulate, brings to the fete a rare talent. His depth of experience in designing manufacturing facilities for Lockheed Aircraft and its major subsidiary firms enables him to advise industrial clients beyond normal architectural limits. His firm, George Vernon Russell & Associates, of Los Angeles, is the major architect for the University of California Riverside campus and is the developer of its new master plan.

DEVICES / SUBURBAN BOSTON

The siting of the building is dictated by the traffic circulation around the plot. Automobile congestion is kept away from the corner by placing the parking facilities at the west and south and delivery and shipment of materials on the west. The organization of the components of the building on the site allows for easier expansion of the plant's individual operations without causing disruption. Expansion to the west of the administration-professional part of the plant will allow the addition of space for a larger engineering staff and enclosure of a landscaped interior court. Expansion of the production wing is accomplished with ease since the space is clear and uncluttered in the initial stage.

Concerning the entrances to the plant, Russell states that an industrial building should be designed as a four-sided building. There should not be a back door and a front door. The loading dock is as important as the office entrance, and can be made just as attractive if some thought is given to its design.

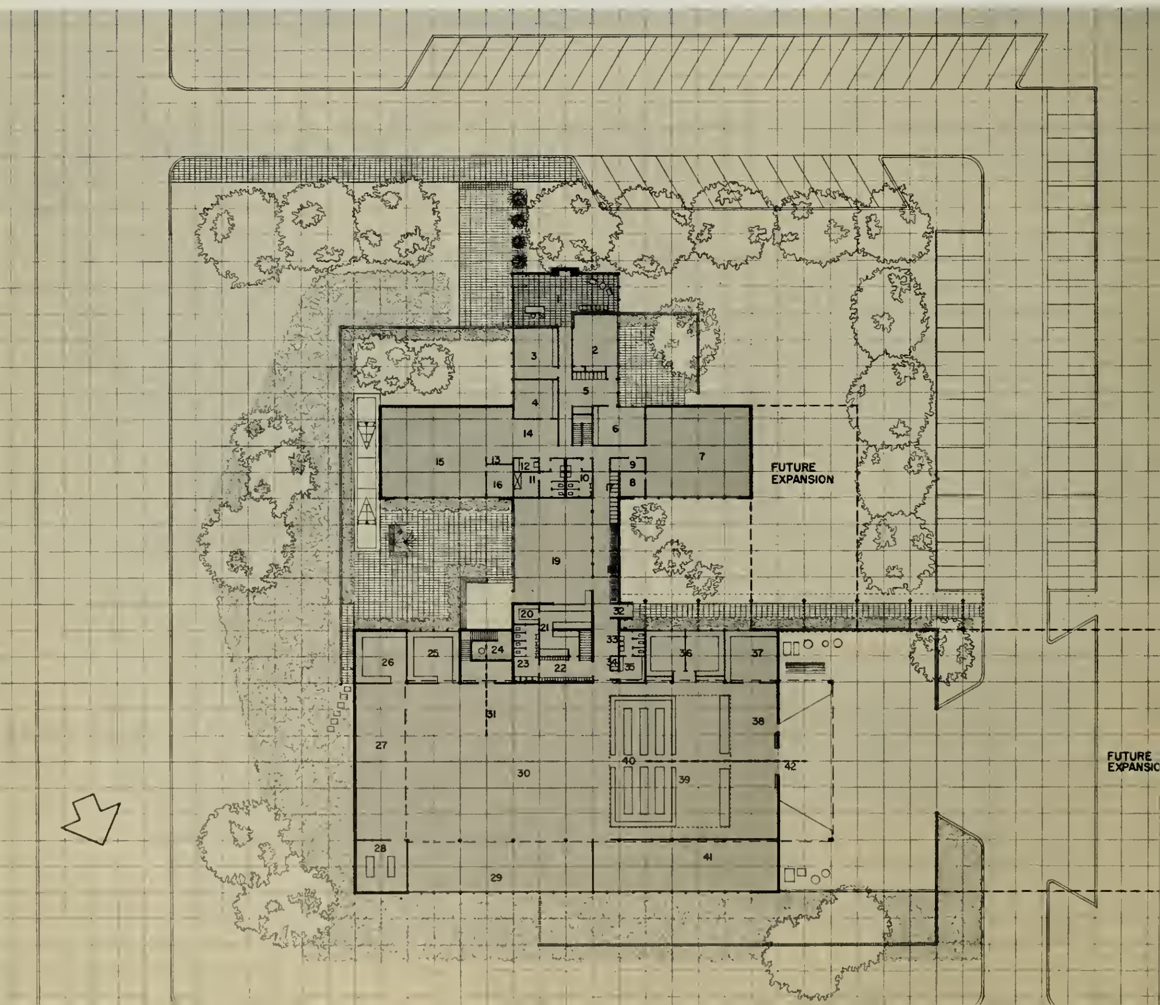
The plan of the plant is based on a 5-foot modular system and the material is predominantly concrete. Over the office and low shop bays, 5-foot wide precast prestressed tapered T-sections are used, and over the higher bays in the production area, 10-foot wide sections with haunches. This roof system allows a clerestory with protecting overhangs. The wall panels are all precast and moveable with gray, glare-reducing plate glass spaced between.

The foundation is poured concrete which extends below the frost line. The basement has membrane waterproofing and furred walls in occupied areas. The ground floor level is 18 inches above the finished grade. The roof system presents a flat profile, but is to support a 40 psf snow load. The factory is completely air conditioned. The flow of heavy materials is serviced by a monorail and hoist system. The special chamber with a radioactive source for testing the devices produced by the plant is located below ground adjacent to the laboratory and component preparation room. A special stairwell faces away from the general plant to allow control of radiation contamination of the testing zone.

The landscaping for Plant A takes full advantage of seasonal changes to provide the variety and environment for the industrial site. The shades, shadows, and growing forms produce a backdrop for the total architecture.

NORTH ELEVATION

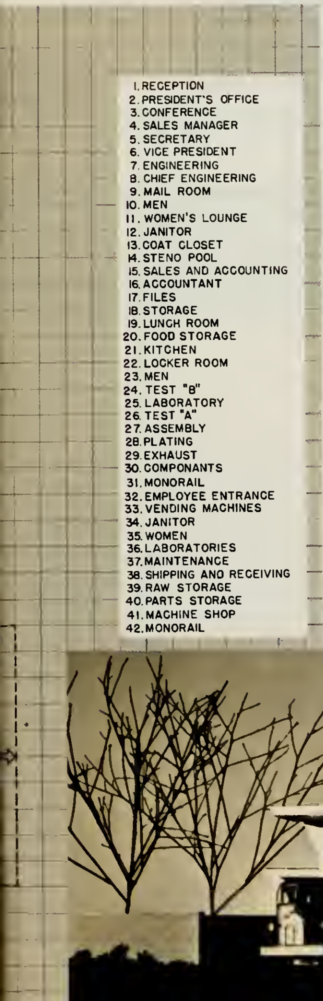
SOUTH ELEVATION



George Vernon Russell

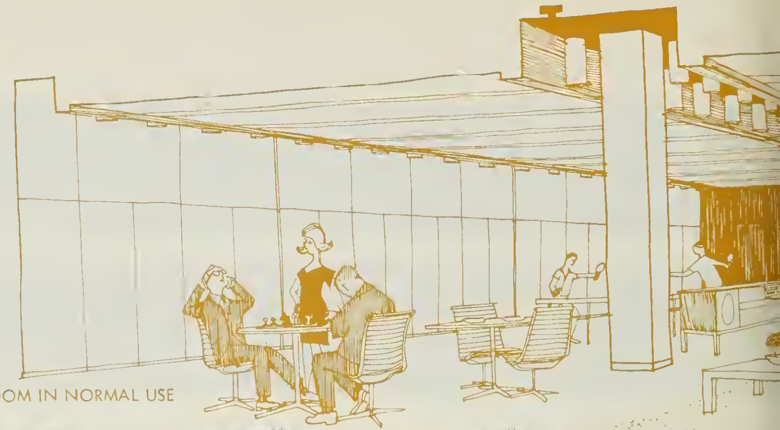
EAST ELEVATION

WEST ELEVATION

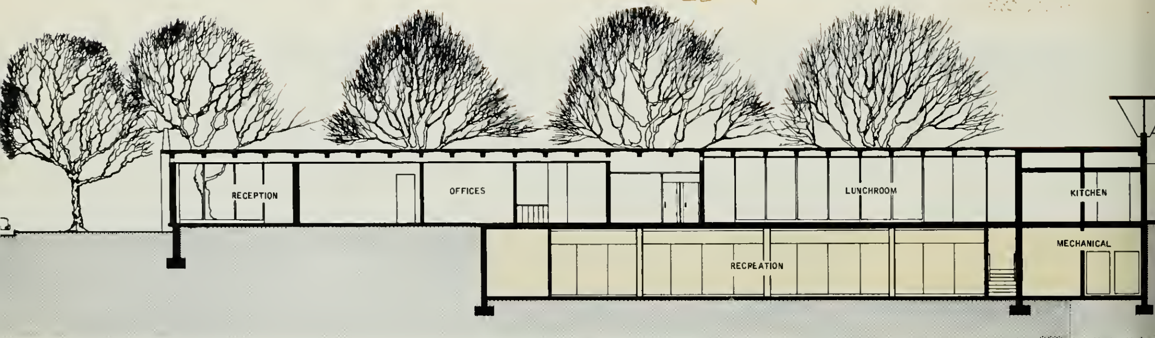


VIEW FROM ENTRANCE (ABOVE)

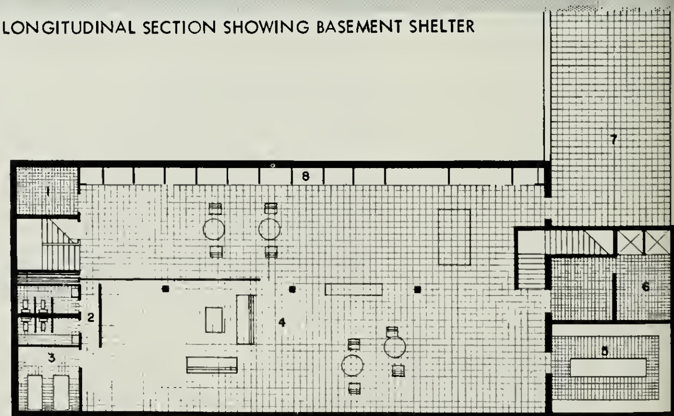
LOADING DOCK (BELOW)



RECREATION ROOM IN NORMAL USE



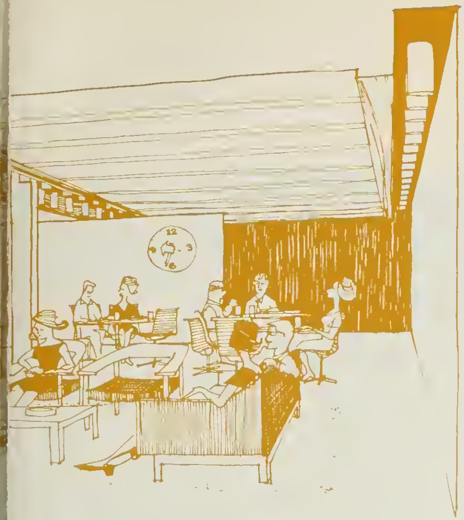
LONGITUDINAL SECTION SHOWING BASEMENT SHELTER

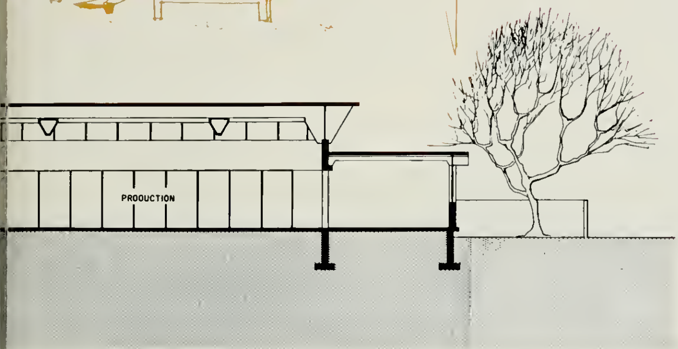


PLAN OF BASEMENT

1. TELEPHONE RELAY ROOM
2. REST ROOMS
3. FIRST AID ROOM
4. RECREATION (SHELTER)
5. STORAGE
6. DECONTAMINATION ROOM
7. MECHANICAL
8. STORAGE

George Vernon Russell





The fallout shelter of Plant A serves as the employee recreation room during normal operation of the plant. It is located in the area below the lunchroom and kitchen and is equidistant from the production and administration-engineering areas. Russell was concerned that any space designated for fallout shelter would be usurped by other plant functions, and his choice of the combination recreation room - fallout shelter seemed to be the optimum solution since it would not be involved in the engineering or production process. Its location under the kitchen enables the kitchen to continue to serve to the employees during a period when it would be used as a shelter. Its placement below grade makes it very easy to meet the required minimum fallout protection factor of 100.

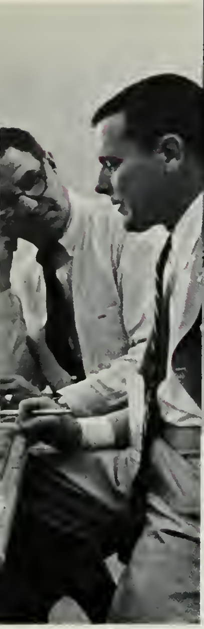
The shelter accommodates 421 inhabitants, and it can be expanded in the future to handle twice this number by linking it to another identical unit through the extension of the mechanical tunnel.

Every attempt is made to insure that the shelter space will be pleasant, and this is carried over into the design details of the room. A folding partition, shown in the accompanying sketch, illustrates how the room may be divided for separation of sleeping from living quarters.

RECREATION ROOM AS FALLOUT SHELTER

view looking toward front entrance

George Vernon Russell



PLANT B NOVELTY

INDUSTRIAL PROGRAM

Products: novelty luggage / Materials: vinyl plastic & duck cloth, small miscellany / Process: job lot, cutting, die cutting, sewing assembly, decoration (silk screen), final assembly, inspection, shipping / Required Facilities: administration, reception, accounting, material control, general offices, manufacturing-engineering, personnel, packing, receiving & shipping, storage, lunch room, silk screen area, dark room, art & design, maintenance, production area / Employees: 100 shop and 15 office (80% women) / Growth: 50%, diversification of present lines / Special Requirements: isolation and special mechanical system for silk screening / Site: suburban Denver, nine acres, graded level, residential community, utilities available, zoned 30% open site.

ARCHITECTURAL SOLUTION

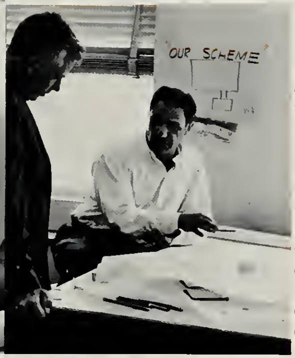
The general philosophy of the architecture of Plant B is to achieve architectural unity. The individual segments of economy, structure, mechanics, landscape, building materials, people, weather are so balanced that none of the elements takes unnecessary precedence. The first step is to know the client, to know what he wants his building to do, then to orient these needs with existing conditions.

Hajjar was faced with four design determinants. First, the plant is located in a residential community. Second, the work force is predominantly women. Third, the facilities are to be completely flexible. Fourth, the silk screening process used in decoration requires special mechanical systems and a degree of isolation.

Plant B is located in Denver on the road to Littleton in a new community of private residences. The design is a deliberate effort to subdue such elements as demonstrative structural shapes in order to eliminate attracting unnecessary attention in a residential area. The plant architecture achieves a peaceful, relaxed attitude. The pitched roof, contour landscaping and indigenous materials fit the residential characteristics of the community.

A factory in a community of young families, which employs mostly women, is able to draw upon a larger selection of workers if a nursery for pre-school age children can be provided in or near the plant. The architect recommended that a child care center be incorporated in the plant facilities, and the owners of the plant accepted this suggestion as a means of providing an attractive fringe benefit.

A. Wm Hajjar



A. William Hajjar, AIA, enthusiastic, sensitive, artistic, has a powerful architectural philosophy. For him the architectural problem is always an aesthetic and human one. He lives and experiences it. Hajjar is currently on leave from his duties as senior design critic in architecture, Pennsylvania State University. He is presently senior staff designer for Vincent G. Kling, Philadelphia. His experience covers residential & apartment building, research laboratories and other building types. He was originator and director of the Pittsburgh Plate Glass grant for the study of air wall construction.

LUGGAGE / SUBURBAN DENVER

Plant B has expanded three times in the past twelve years; therefore, flexibility must be an integral ingredient of the design. The original mass of the building is kept simple to allow expansion units of 40 by 40 feet to be attached to the body of the building with a feeling of orderly growth. The relatively inflexible and complex mechanical system which forms the core in the building around the silk screen room is placed in the front interior bay of the building. This leaves the sides of the building completely flexible on both the east and the west.

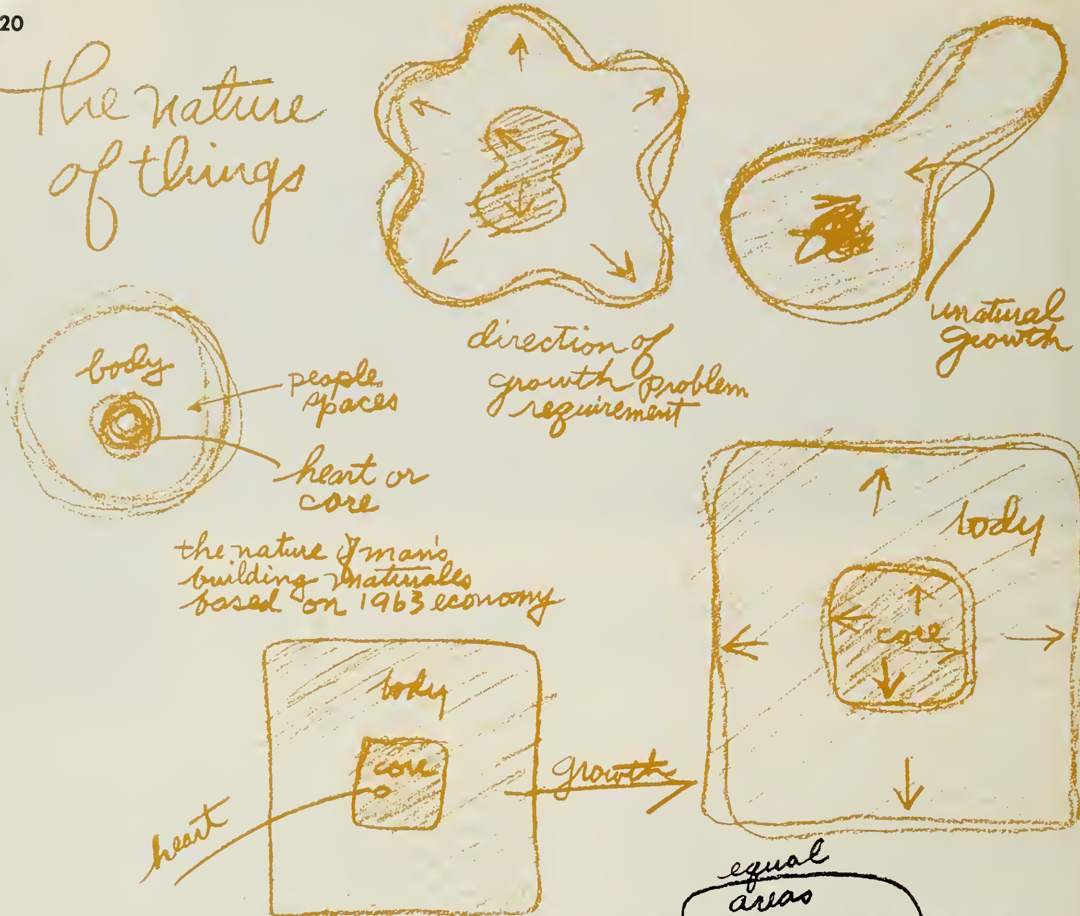
The general disposition of elements of the plan are arranged with shipping and receiving and the storage area for raw materials and finished goods on the north. These storage rooms act as a buffer from the harsh weather. The central core - the open court and silk screen room — is flanked on the east by cutting, reroll, and assembly, and on the west by finishing assembly, both areas with physical activity. Toilet facilities are placed on either side of the central core and are accessible from the outside corridor and from the silk screen room. The south side of the building houses the offices.

In keeping with the residential character of the neighborhood and the backdrop of the Rocky Mountains on the west, a pitched roof is employed. It is supported by an open steel truss system. The mechanical, electrical and heating systems are carried in this space from the mechanical core around the silk screen room. The roof itself, similar in appearance to the shingled roofs of residential architecture, is sandwiched metal sheets, 4 inches thick in 12 foot panels. The discipline of the roof forces an orderly, but not formal result to the overall plan. Rectilinear shapes were used because they are the easiest to erect and the most economical building components, but the landscaping follows a flowing, natural curve.

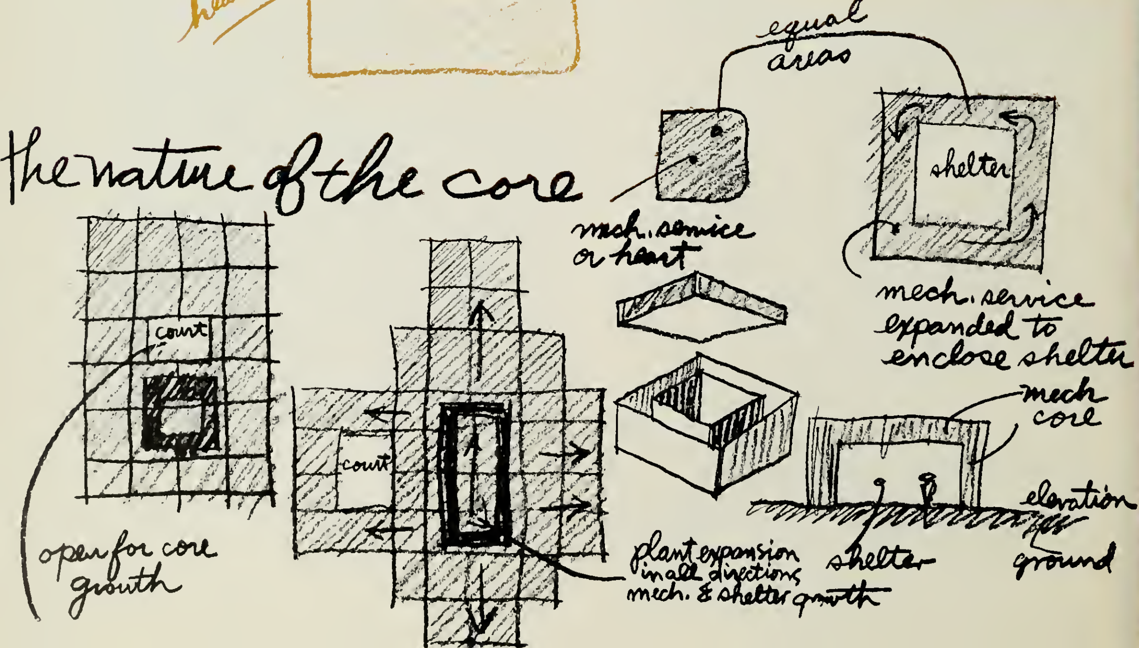
Rectilinear site lines do not exist on undeveloped terrain - one has to put out flags or pins even to see the boundaries. Hajjar thus followed a curvilinear site development scheme, one more natural to the movement of vehicles and people. An elliptical valley scooped by bulldozers acts as a venturi to channel the wind and direct it around the building. The elevated contours of the landscape and the roof overhangs keep out the high summer sun, but allow the low winter sun to warm the factory through the glass wall on the south. This natural barrier, which is a part of the landscaping is important to climate control and contributes to fallout protection.

The silk screen room is the least flexible of the function areas of the plant because of the mechanical systems needed for controlled humidity, fire protection, and exhaust of toxic fumes. The expansion area is provided in the interior court adjacent to silk screening, and this open court is a window for the workers and provides natural ventilation. The mechanical system which is wrapped around this space isolates the silk screen area, thus creating a great dividing wall with the mass of the equipment. The mechanical system is also carried into the attic space and acts as another layer of protective mass. This silk screen space, acting in a dual capacity, is the ideal location for a fallout shelter in Plant B.

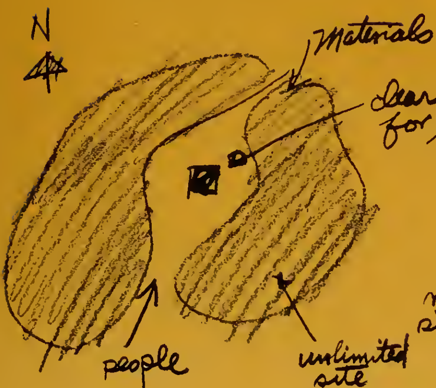
the nature of things

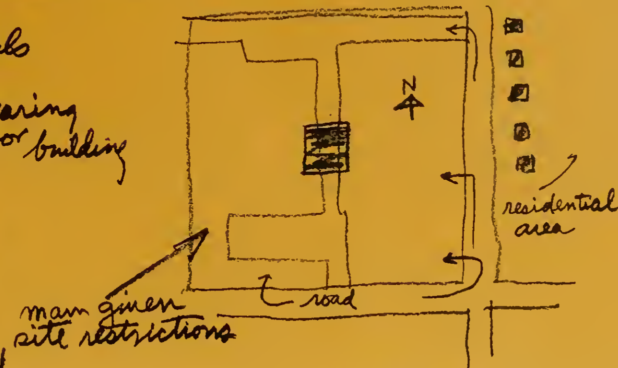


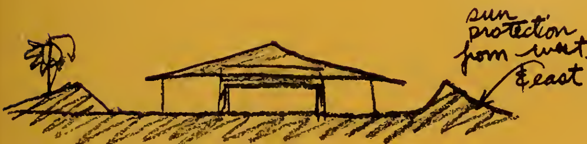
the nature of the core



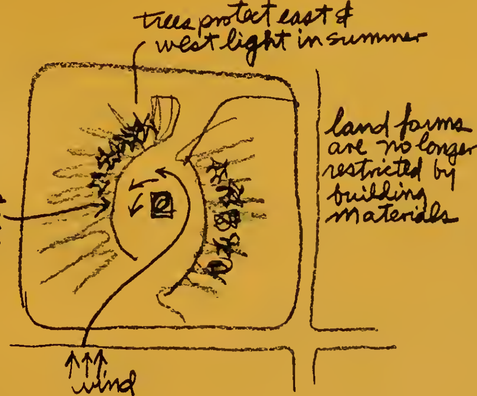
land & Climate — Colorado



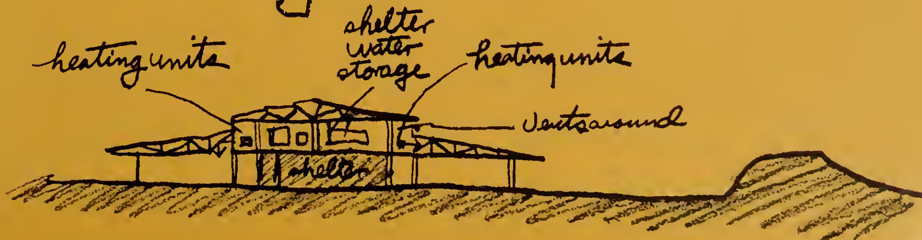




earth walls serve 3 purposes
protection of E.W. light—catch
summer breezes & add shelter
protection



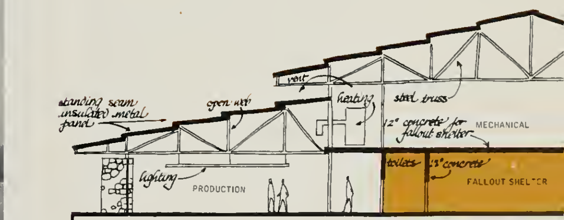
Elec. made. system



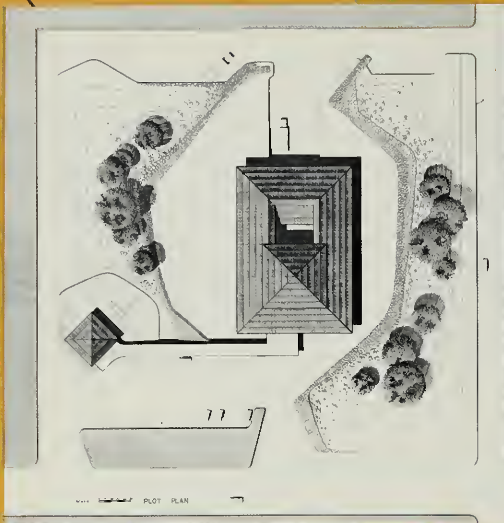
A. Wm Hajjar

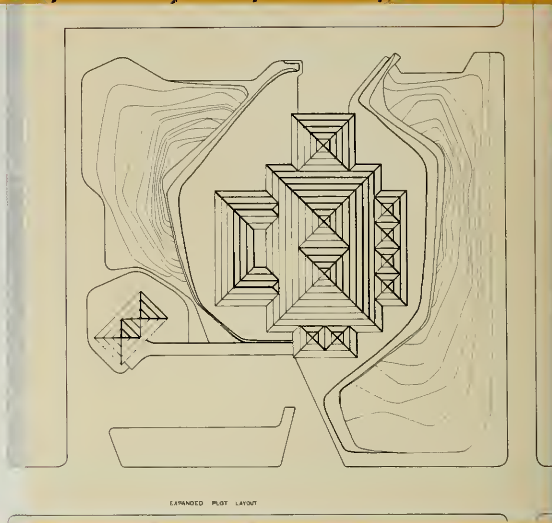
The central first floor core of Plant B is the dual-use fallout shelter. It is also the silk screening room and very few special structural and mechanical considerations were required to make this room serve both purposes. The wall barrier is created by enclosing this space with toilets and storage rooms. The protection above is furnished by the attic space in the pitched roof which contains mechanical equipment and is sufficiently large to store water, bunks, food stuffs and other necessities for emergencies. Additional protection from ground direct radiation and skyshine is gained by the mounding of the earth in the landscaping around the building. The protection factor is further increased by the large fallout-free factory area surrounding the core. This space also allows expansion of the shelter area after the radiation intensity has fallen to a safe level. As the building expands, each new unit will add to the protection factor by creating additional barriers.

On the basis of 10 square feet per person, the silk screen area will serve as shelter for 490 persons.

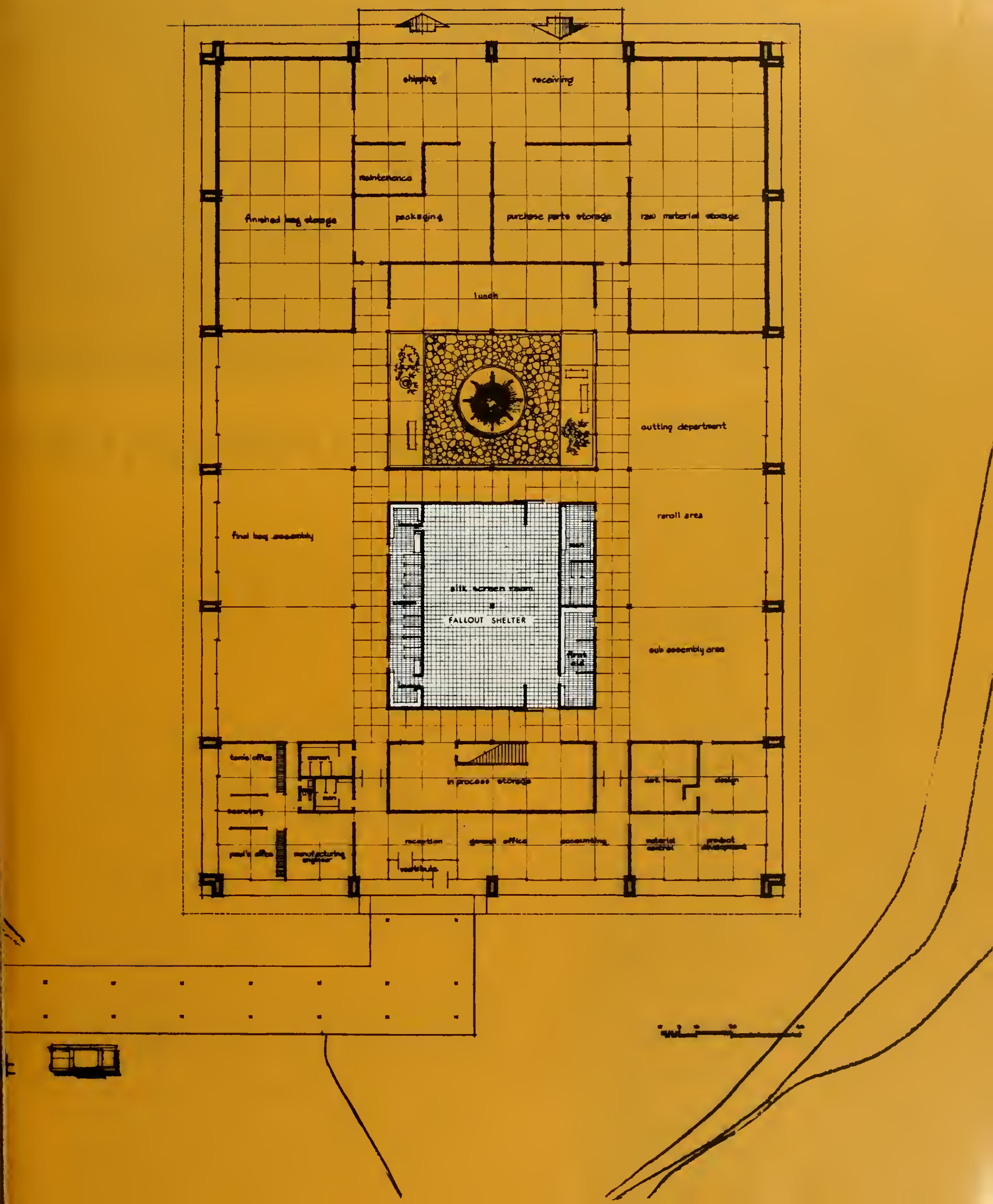


SECTION THROUGH FACTORY


PLOT PLAN


EXPANDED PLOT LAYOUT


nursery


shipping
receiving
maintenance
finished bag storage
packaging
purchase parts storage
raw material storage
lunch
cutting department
reroll area
final bag assembly
silk screen room
FALLOUT SHELTER
sub assembly area
in process storage
design
secretary
manufacturing engineer
reception
general office
accounting
material control
product development
vestibule

PLANT C METAL FURNITURE

INDUSTRIAL PROGRAM

Products: metal furniture / Materials: iron rods, chromium tubing, castings, steel plate, strip steel, wood, vinyl & duran upholstery, padding, small parts / Process: job lot, cutting, forming, polishing, arc-welding, pressing, painting, padding, upholstering, assembly, packing & shipping / Required Facilities: general office, private office, reception, display, railroad siding, upholstery & assembly, paint storage & booth with drying ovens, storage, access for fork-lift trucks, electrical hoist & monorail / Employees: 200, over half women / Special Requirements: fire wall (paint area & arc-welding) Site: St. Louis County, ten acres, railroad siding, all utilities.

ARCHITECTURAL SOLUTION

Plant C is planned for expansion in three stages in increments of 25,000 square feet. This provision for future expansion was one of the criteria which Heery insisted upon as a consistent rule of successful plant design.

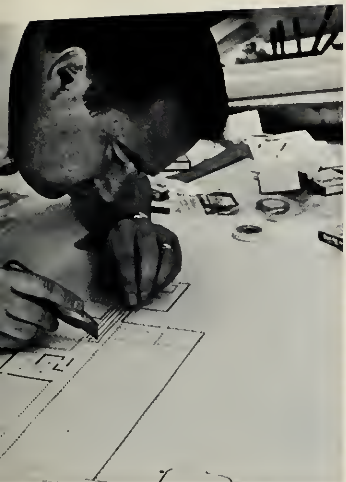
"A manufacturer either grows or disappears. Room for this growth and a plan for expansion are musts."

Another primary concern is for flexibility of the plant.

The architecture of Plant C is compatible with these two aims, and it accomplishes them with a wary eye toward the involved cost — both initial and future — and without sacrificing appearance. The straightforward approach to the solution of the clients' problems eliminates much of the expense inherent in industrial development.

The site is located in a planned industrial neighborhood and is large enough to permit adequate space for parking and expansion and maintenance of the value of the real estate as an investment.

"The only thing that one knows for certain about a given manufacturing operation is that it will change. Flexibility should be one of the bases of the design. The architect who fails to provide flexibility, fails his task."



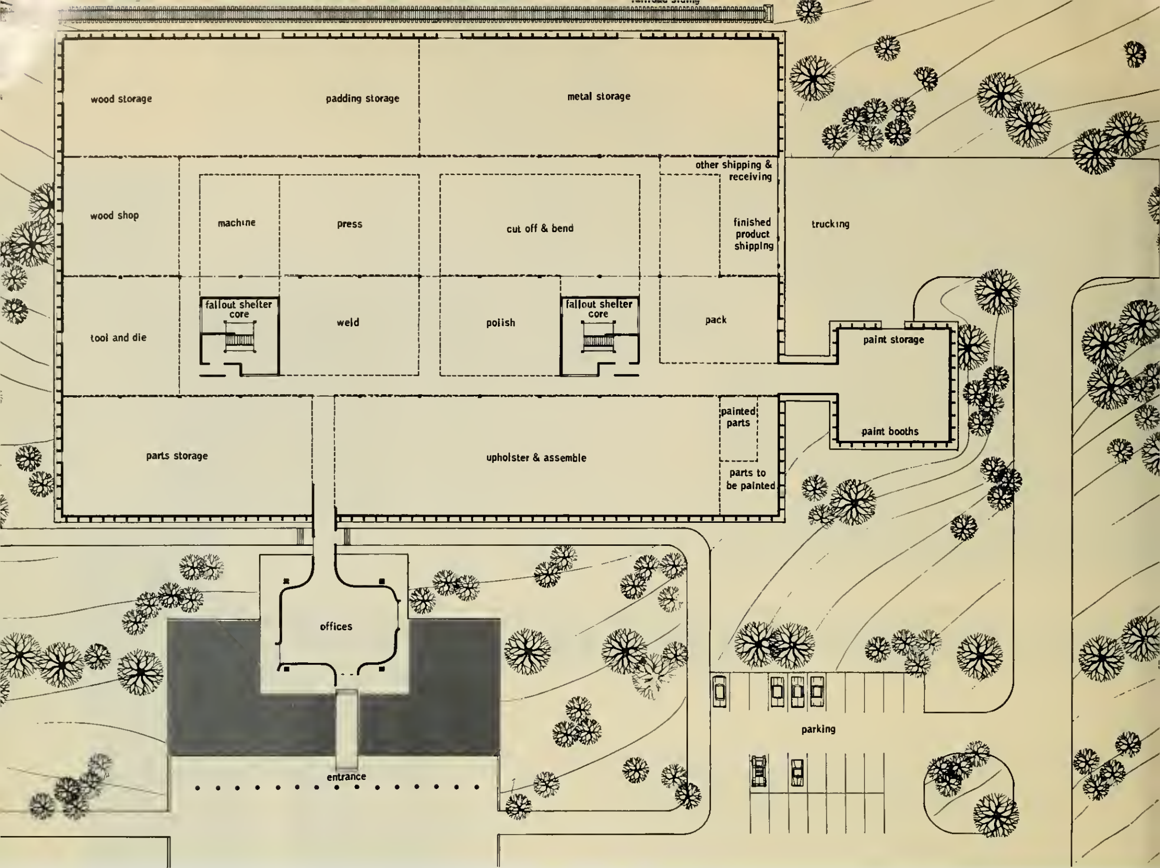
/ ST. LOUIS COUNTY

In its final stage of growth as presented here, the building consists of the large production area with two adjunctive buildings. One of these is for administration, located at the front entrance, and the other is for the paint shop, segregated to eliminate the necessity of a firewall within the factory. The administrative wing receives special design treatment and becomes a symbol of the company to the public. The selection of materials — concrete and brick in a special pattern — and the custom interior furnishings make this space an intricate point of emphasis against the backdrop of the repetitive pattern of the facade of the plant. Special attention is also given to the landscape features of this entrance. A large reflection pool and paved approach establish a suitable character for this introductory space to the plant.

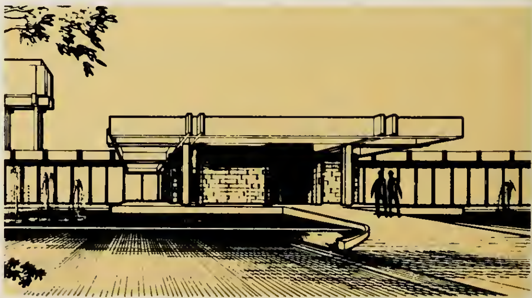
The steel structural system comprises supporting wall panels and roof joists of pre-stressed, precast concrete units. The decision to use the steel framing system is made because of its value in a plant for the attachment of continuously changing lighting and power distribution, air and gas lines, sprinkler system, and other process systems. The long span concrete roof T-joists span 60 feet and allow large column-free spaces within the plant for adaptation to future placement of the machinery. Two feet of additional clear height beyond that presently required is provided as still another provision against obsolescence of the physical enclosure.

Within the plant production space are two cores. These contain employee lockers, toilets and lounges. This area is dual-use space for a fallout shelter in time of emergency. Directly above each of the cores is a water storage tank that projects high above the roof line in dramatic silhouette.

The architectural design of Plant C is attractive, functional, expandable, and economical. It is a suitable tribute to the intentions expressed by the architect, "A manufacturing plant is a tool of industry. Its functional requirements can not be logically compromised, and there is no reason why it should not be a handsome building."

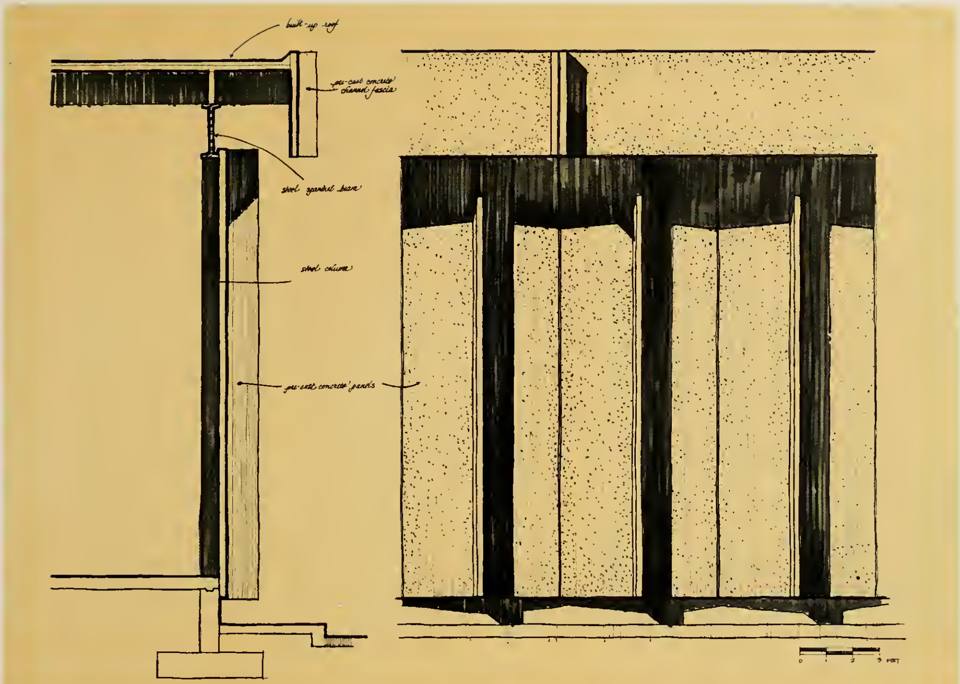


FLOOR PLAN



ENTRANCE PERSPECTIVE

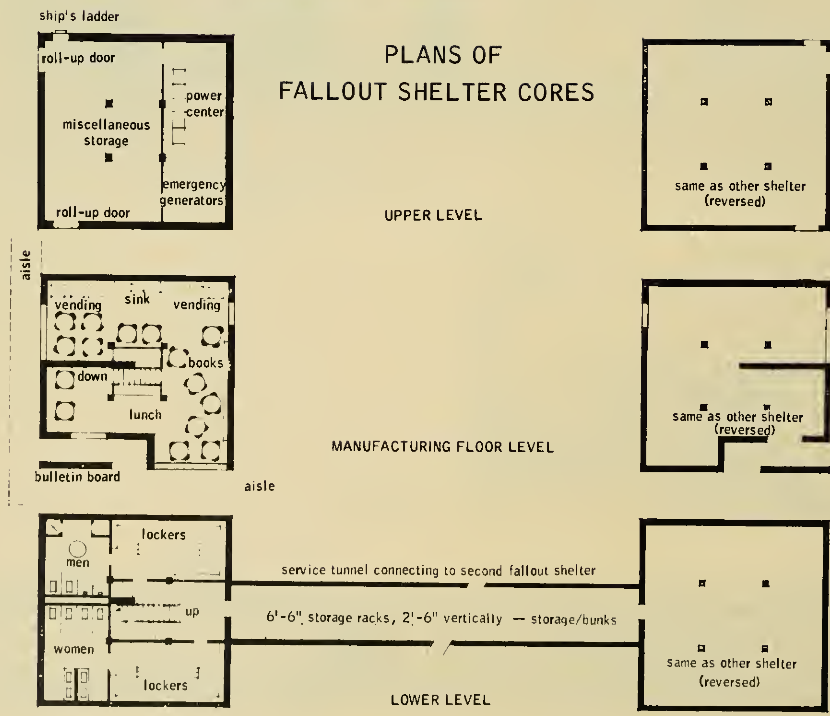
FRONT ELEVATION

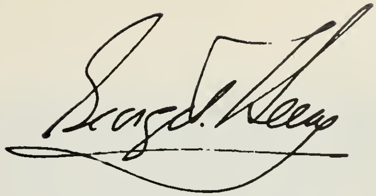


TYPICAL WALL SECTION

TYPICAL WALL ELEVATION

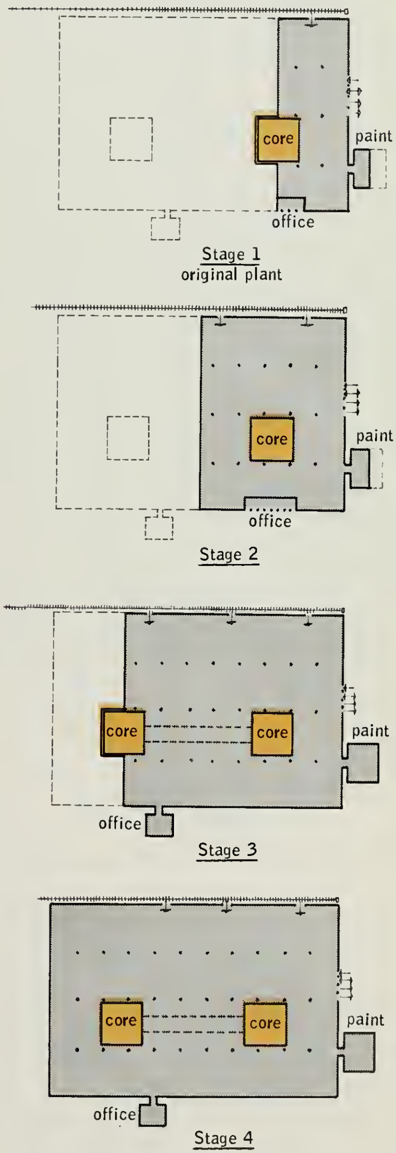
PLANS OF FALLOUT SHELTER CORES





Heery's fallout shelter for Plant C will accommodate 1155 people. There are actually two shelters in the completed plant, one in each core. Each core contains three levels: (1) basement, the locker and toilet area, (2) ground level, the vending machine lunchroom, and (3) the second level, the storage and mechanical equipment area. A tunnel connects the basements of the two fallout shelters and serves as a dormitory for both. The occupants are protected by the earth fill and concrete walls at the lower level, by the thickness of the exterior and core walls, and by the distance between the two upper levels.

The handling of elements within this vertical core space is a utilization of the changes in levels. The second level is a mezzanine space around the stair leading to the lower level, and the spaciousness of this mezzanine is increased by the use of a twin-layered glass wall with an aquarium in the space between.



EXPANSION STAGING

over-all view of site looking toward front entrance

PLANT D FOOD

INDUSTRIAL PROGRAM

Products: food handling equipment / Materials: stainless steel & aluminum, small parts / Process: job lot, small parts in large quantities and stored, large parts move in assembly, shearing, hydraulic presses, subassembly, assembly, spot welding, testing & inspection, shipping / Required Facilities: administration, conference room, four private offices, accounting, production control, display room, lunch room, receiving & shipping, storage for sheet metal, in-process goods and finished merchandise, sub-assembly, final assembly, tool room / Employees: 55 / Special Requirements: cleanliness, ventilation for metal working machines, flow of materials important / Site: Atlanta, industrial park, 50% open site required, gradual slope to rear, all utilities.

ARCHITECTURAL SOLUTION

The solution of any design problem accepts as its first premise the need to satisfy the functional requirements of the program. Many solutions satisfy only the functional requirements and stop. The design of Plant D satisfies these requirements and much more. The architect was not content to merely house the production process, nor was he satisfied to provide only adequate space for the efficient operation of machines and workers. He strove to make his plant do these things, but to do them in a way that would evoke a response of pride in those who used the buildings and a response of admiration from those who view the building.

The architecture for Plant D consists of two buildings — one for the administrative offices of the company and one for the production phase of the operation. This division seems natural to Bassetti who described the office spaces as the "brains" of the organization and the production plant as the "muscles." The solution of both parts of the plant is predicated on a strong structural concept and each derives its appearance from the honest expression of this structure. Since their functions are different in nature, the design for each is also quite different. The character of the office building is distinctive with refined proportions and forms with a change of materials, while the factory has a rugged quality of strength and massive structure.

Fred Bassetti

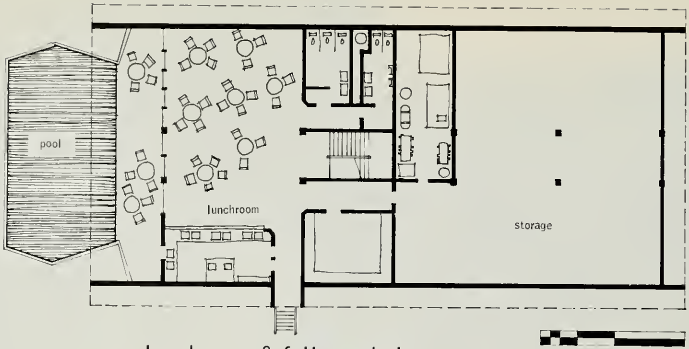
Fred Bassetti, AIA, is a rare combination of the practical problem solver, the aesthete, and the humanist. He wants each of his designs to express its specific purpose, to belong to its environment, and to work for the client and for the people who will spend their time in his buildings. His Seattle firm, Fred Bassetti and Company, has had a wide range of architectural and planning practice, from private and military housing and apartment units, to medical clinics, schools of all levels, university facilities and commercial projects.

HANDLING EQUIPMENT / ATLANTA

The factory building is built of precast concrete units - columns, beams, roof units, and wall panels - which are fabricated on site. These units are far from being stock prefabricated items. Each is especially designed for the job it is to do. The joinery of the various parts is made through the use of overlapping ridges and flanges on the beams and columns. The unique and original system of construction allows Bassetti to cover the 46,000 square feet of factory using only six interior columns. The basic module of the factory is composed of 20-foot square, precast concrete pyramids with skylights at the apex of the pyramids tilted northward for natural light. Wooden sun shades of redwood slats rest between each of the concrete pyramids. This sun shading lowers the temperature inside the factory several degrees and makes air conditioning in the production areas unnecessary. Natural ventilation is also possible through the vertical windows between the tilt-up construction wall panels.

Because of Bassetti's decision to make the two buildings autonomous according to functional requirements, the administration building employs a structural system, materials, and forms intentionally contrasting with the factory building. The office building is a load-bearing wall system on two levels. The first floor is raised above grade 4 feet to allow a strip window at one end of the basement and a full glass wall at the other end looking out on a reflection pool, also located below grade. The construction of the pitched roof is made of precast concrete roof panels of 8-foot widths, corrugated in a pattern of ridges and valleys to conform to the exact load requirements as the section of the panels changes. The raised portion of the roof at the ridge contains the attic space for the distribution of the major mechanical ducts. The roof panels are supported by U-shaped brick exterior walls and a central row of load bearing interior partitions. A variety of interior spaces is obtained in the offices by the use of curvilinear walls, allowing free movement of office personnel. The cafeteria below the administrative offices is a very pleasant environment with its glass wall overlooking the landscaped pool. This semi-basement space doubles as the fallout shelter for Plant D.

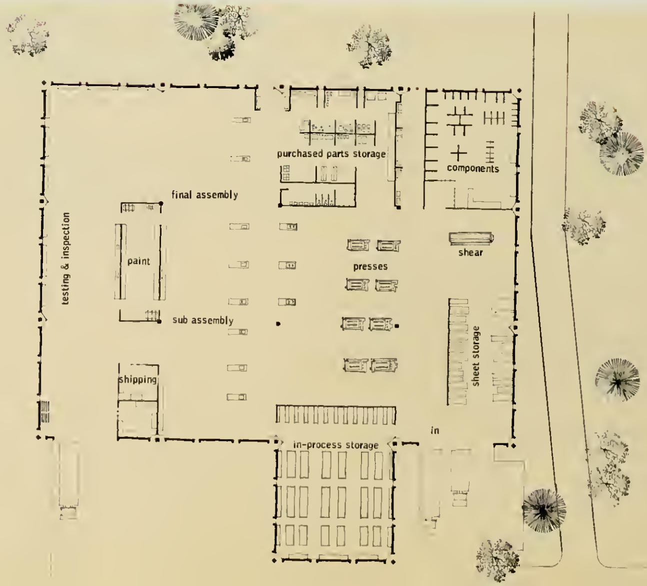
The architecture of Plant D is a conscious effort on the part of the architect to let the design grow from its natural conditions as they relate to the occupants or the machinery. Its impression is one of efficiency and beauty.



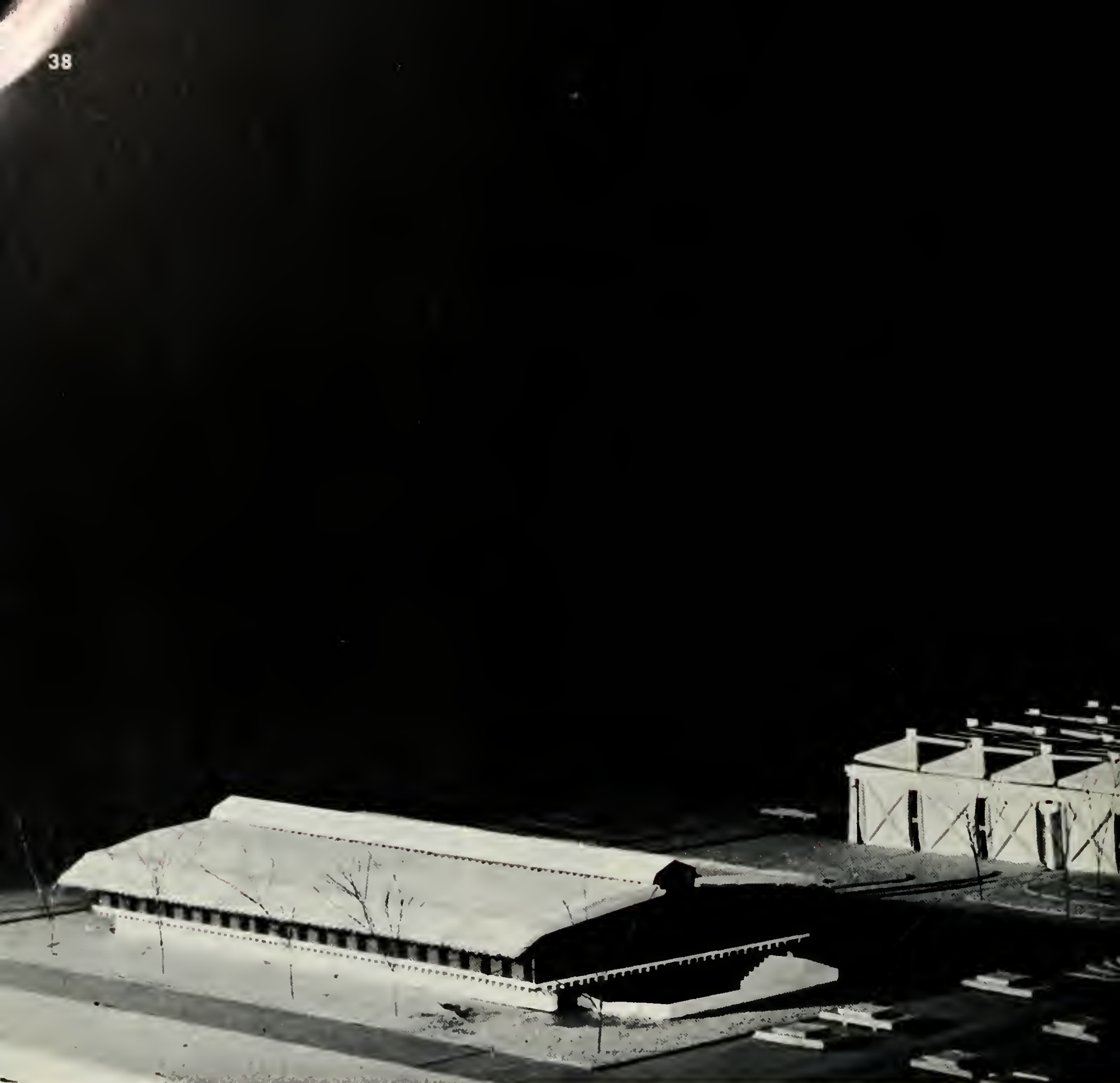
lunch area & fallout shelter

GENERAL OFFICE

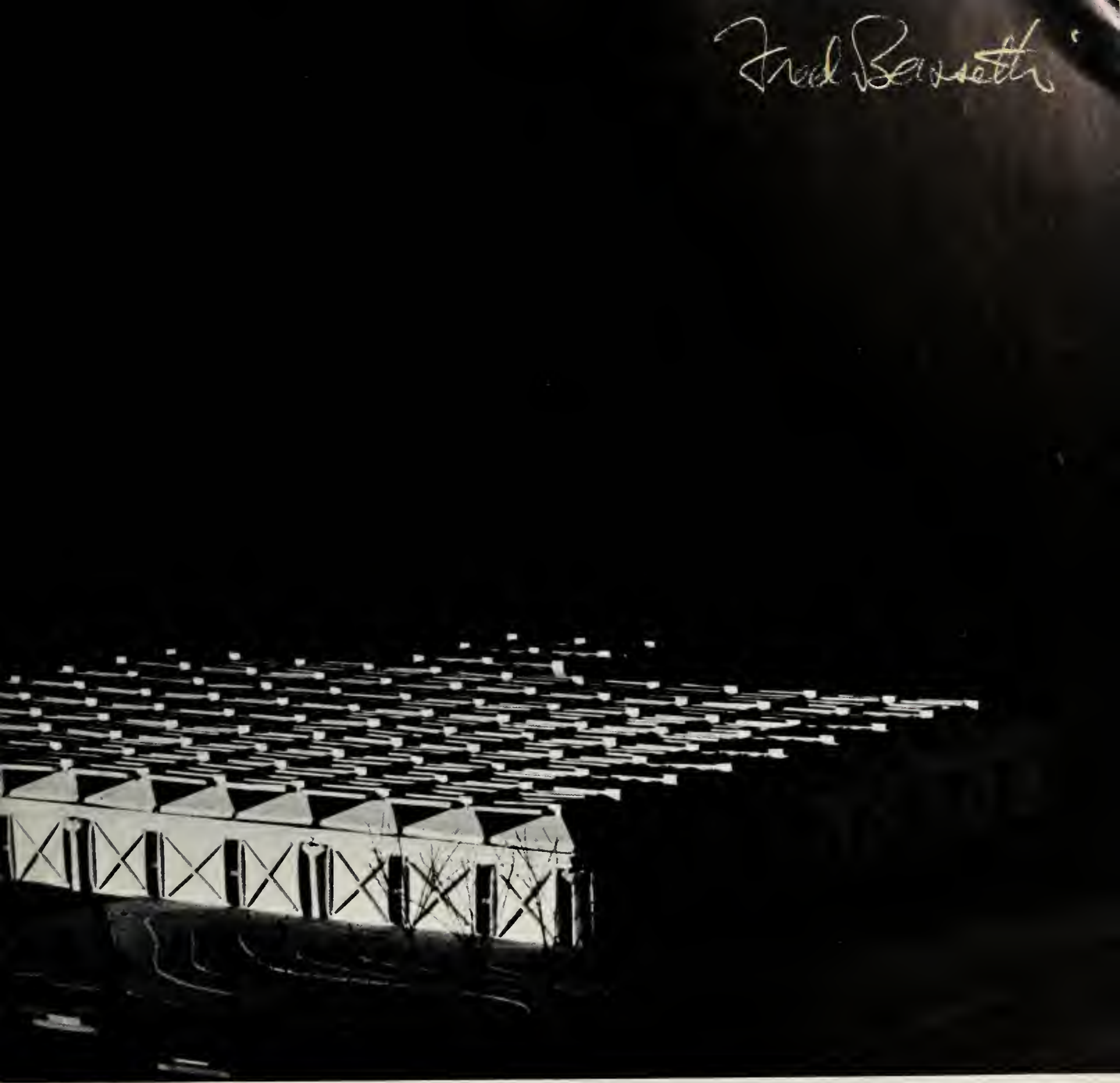
1. foyer
2. display room
3. sales & promotion
4. printing
5. engineering
6. accounting
7. superintendent & production control
8. management
9. conference room
10. president
11. lunchroom & shelter
12. pool

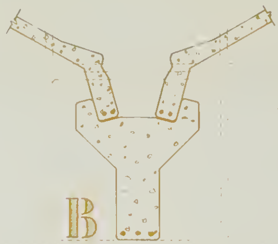



Fred Barretti

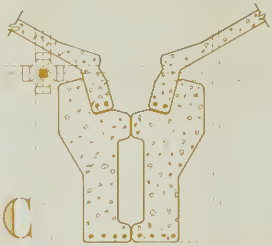


overall view of plant from above


Fred



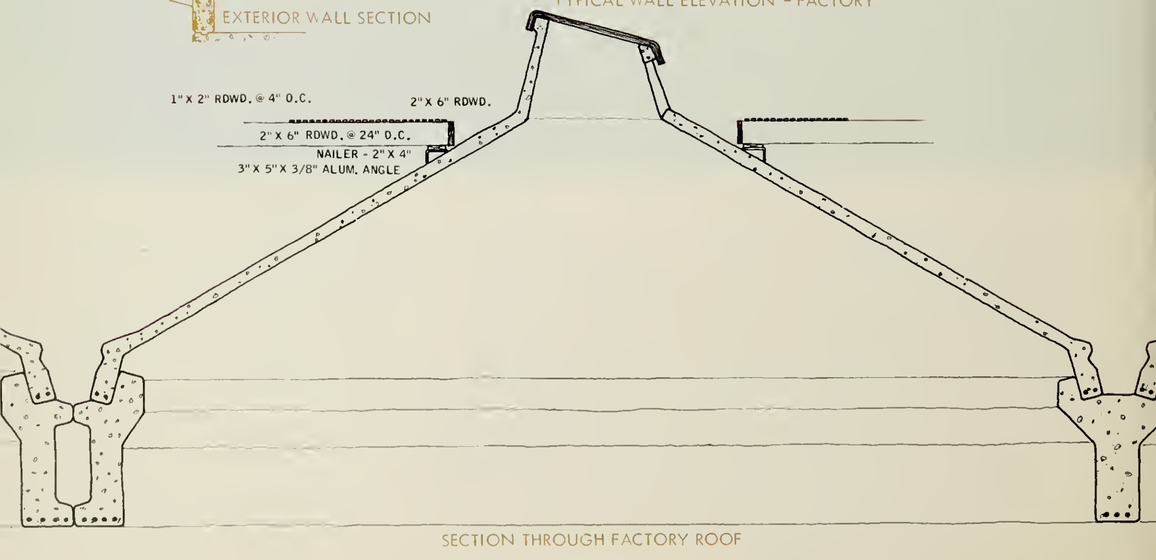
SINGLE BEAM SECTION



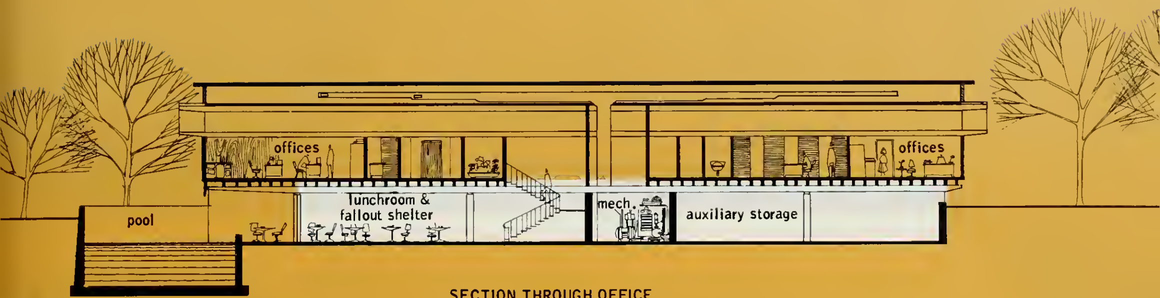
DOUBLE BEAM SECTION

TYPICAL WALL ELEVATION – FACTORY

EXTERIOR WALL SECTION



SECTION THROUGH FACTORY ROOF



SECTION THROUGH OFFICE

The fallout shelter in Plant D will accommodate 650 persons. It strongly emphasizes psychological considerations of shelter design, and at the same time more than adequately meets the protection factor of 100.

Bassetti's shelter is in the employee lunchroom in the basement of the administration building. The sloping nature of the site permits full floor-to-ceiling fenestration on the entire width of the room overlooking the reflection pool. By this use of a glass wall, any feeling of being closed in was avoided. Skyshine contribution in this space is limited by an oversized spandrel beam above the glass. Ground direct contribution is limited by an extension of the abovegrade retaining wall around the reflection pool. The fallout in the pool is not a hazard because it settles and the depth of the water provides an effective barrier.

The additional storage space in the basement will be used for shelter supplies and storage of records and files of the administrative offices.

PLANT E PLASTIC

INDUSTRIAL PROGRAM

Products: molded plastic containers / Materials: synthetic resin and colorants, both arrive by rail and stored in silos and drums/ Process: air-operated bulk handling devices, machine hoppers, molding machines, belt conveyors, secondary operations, flash and trim operations, packing, shipping, silk screen or hot stamp decoration, storage / Required Facilities: rail siding, silos, storage, maintenance and tool room, compressors, storage for inflammables, compounding room, molding, secondary operations, decorating, general office, six private offices, conference room, cafeteria, first aid room / Employees: 85, with 65 on 24-hour basis / Special Requirements: heavy mechanical systems, exhaust in molding area, heavy machinery, extreme noise, extreme cleanliness / Site: SE metropolitan Los Angeles, nine acres, all utilities, no restrictions on site, no climate problems.

ARCHITECTURAL SOLUTION

The architect solves the problems of Plant E with a high degree of sophistication. The appearance of simplicity is misleading and disguises the ingenuity displayed in the solution of the complex functional requirements of the plant. The architect attacked the problem by first scheduling the detailed needs and then evolving the large scheme from the concept. The planning of the plant is based on a modular system of bays 50-feet square. This module allows location of the various functions of the plant according to use-relationship and permits an asymmetrical composition of elements that adheres to the production flow of materials and operations within the plant. Through use of this system, it is possible for the plant to grow freely as its needs require without being restricted by a rigidly established pattern of growth.

The segregation, but not separation, of the administrative portion of the plant from production is made possible by projecting two of the modular bays to the front — one enclosing the offices, the other acting as an open entrance pavilion. Public access to the administration is separated from the employee entrance which is located on the east side of the plant adjacent a large employee parking lot.

Don Hisaka

Dan M. Hisaka, AIA, sensitive, young, and energetic, manifests a mature and analytical grasp of architecture. He is always preoccupied with aesthetic values, but in a way that works towards sound organic and functional design. His creative talent, however, does not preclude a great concern for the economic considerations. Before starting his own firm in Cleveland, Don Hisaka, Architects, he was director of design for Minoru Yamasaki and Associates, Birmingham, Michigan. In 1961 he won the Progressive Architecture Design Award for an urban renewal and low cost housing project in Milwaukee.

CONTAINERS / LOS ANGELES

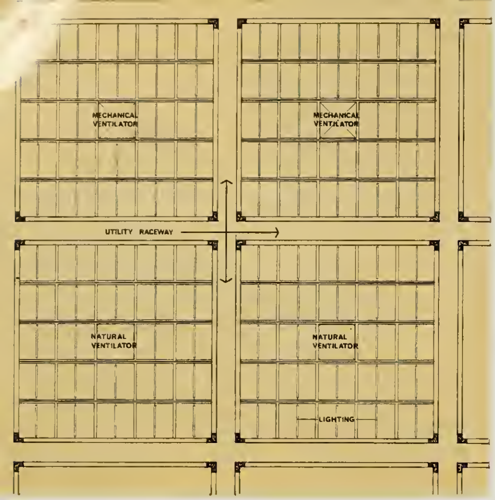
The two levels of the administrative offices, which are housed in a single bay, are situated around an open light well. This same well supplies light to a subgrade cafeteria court with a fountain (see section of light well).

The employees enter the plant at the basement level where the lockers and the cafeteria are located. This area below grade is the dual-use space which doubles as a fallout shelter.

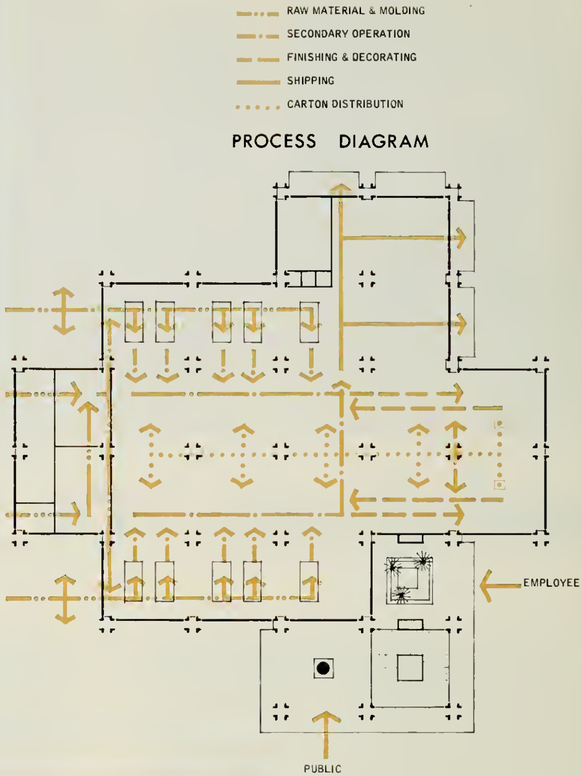
The overall scale of Plant E is derived from the size of the large molding machines for shaping the plastic containers produced by the factory. Since these machines and their gigantic size and mechanical requirements are the dominant factor to be considered in the design of the plant, it seems logical that the scale of the building should reflect their shape and function rather than humanize the scale of the building in an attempt to de-emphasize and hide the machines. These machines produce tremendous heat during operation and for this reason they are located toward the perimeter of the building. Two molding machines can be contained in each of the 50 x 50 foot bays. Weather is not a major design determinant, thus weather conditioning does not establish the air conditioning of the factory, but the machines require special exhaust. Thus, over each of the bays in the plant is a "box" structure on the roof which may be used for mechanical or natural ventilation or for a skylight, depending upon the need of the production area below. Four towers located on the rail siding on the west side of the plant adopt forms similar to the roof profile to retain the design continuity. These towers are resin storage containers and an incinerator.

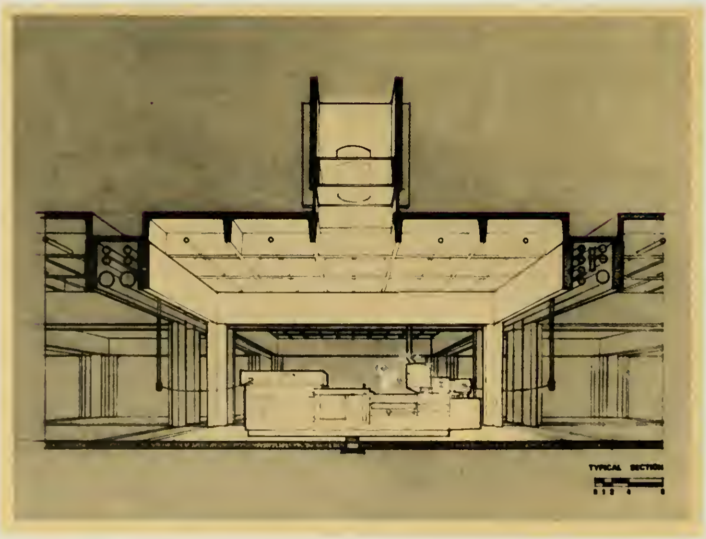
The key to the simplicity and workability of the solution for Plant E lies in the synthesis of the structural, functional and utilitarian parts into one modular system. The structural system is based on a repetitive use of precast, pre-stressed, post-tensioned concrete beams supported by precast concrete columns. This post and beam system encircles each 50 x 50 foot bay creating a cluster of L-shaped columns where the bays join corners. Since each bay has a free standing beam system, space between the beams of adjoining bays creates a partially concealed raceway for the distribution of the variety of utility lines. In such a system the normal disordered appearance of a factory is avoided, and it is ideally suited for easy repairs as well as for future additions and alterations.

Although the scale of the factory is based on the machines of the production process, close attention is given toward making the plant a pleasant and attractive place in which to work. The bold beauty of the white forms, the courts and fountains, and the abundant landscaping relate the building to its surroundings and to its occupants.

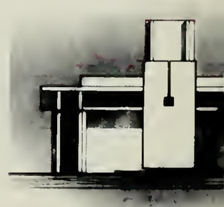


REFLECTED CEILING PLAN

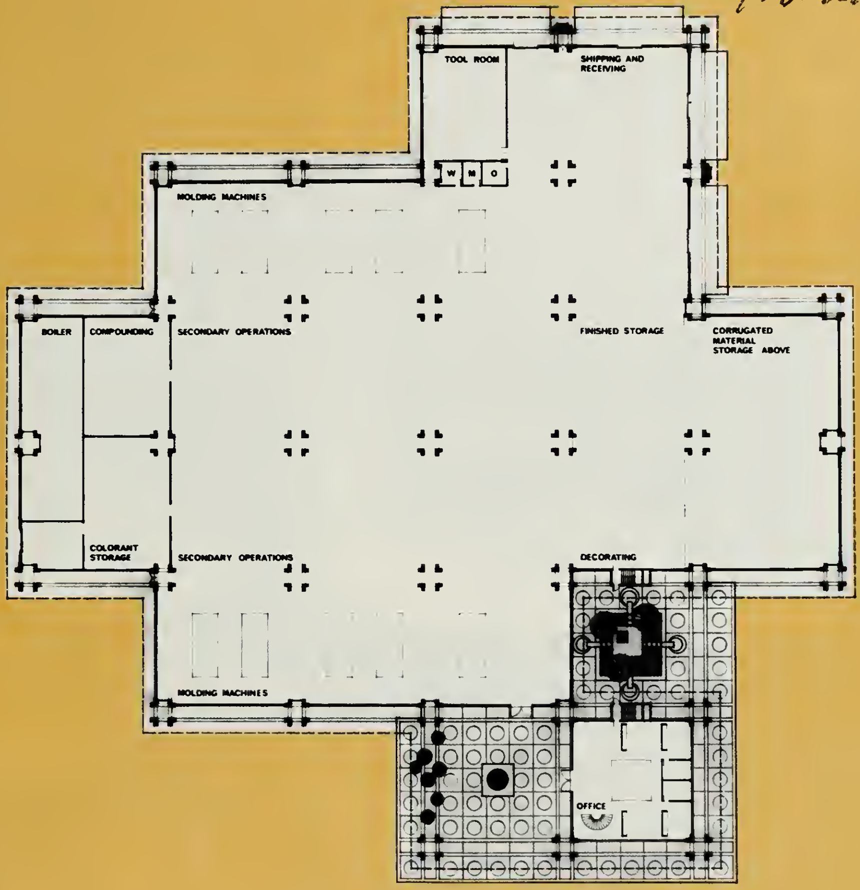




TYPICAL SECTION

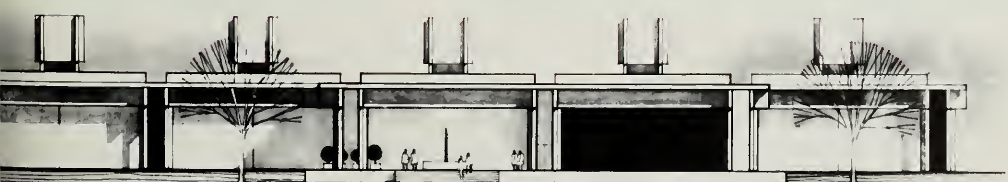


Don Hisaka

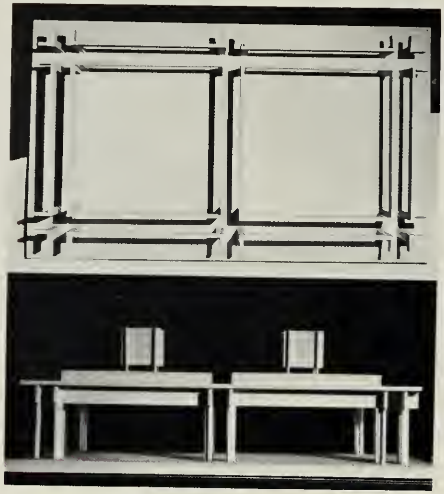


FACTORY PLAN

NORTH

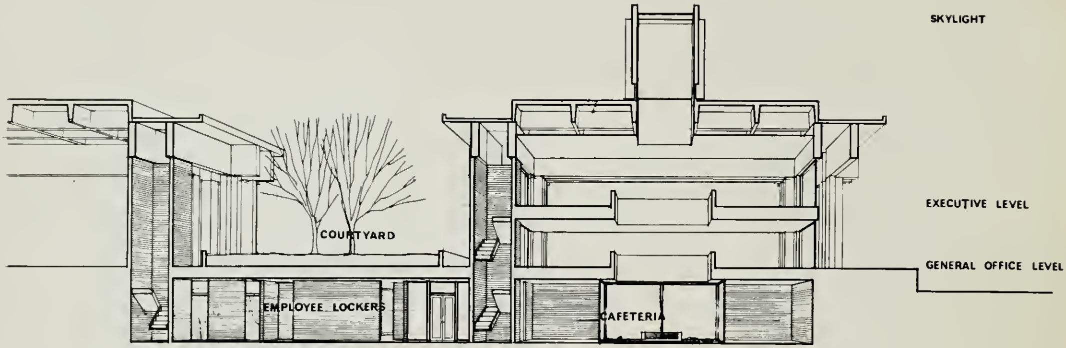


SOUTHWEST ELEVATION



Model of two typical bays showing elevation (lower) and structure with roof removed (upper).

Don Hisaka



SECTION A·A

FALLOUT SHELTER LEVEL

fallout shelter plan (577 persons)

SERVICE COMPLEX

0 2 4 8 16

Hisaka made the decision of using the cafeteria in the basement of the administration wing as his fallout shelter. This dual-use space, although located below grade, is a pleasant area facing onto an enclosed central court lighted by an air well. The court is landscaped and well lighted by the light well which continues up through the two administrative floors to the large skylight in the roof. The occupants of this space will be protected from the roof contribution by a total of nearly twenty-five inches of concrete in the floors and roof (see section) as well as the distance factor from the roof to the shelter area. Hisaka found that the use of the skylight did not lower the required protection factor of 100 because of its limited size and geometric location at a distance. The psychological benefits derived from the planning of the well-lit and attractive shelter are obvious.

The remainder of the shelter area is in an adjoining locker and toilet room, accessible from the parking lot by a ground level entrance. This space achieves its protection by a twelve-inch concrete slab roof with two feet of earth fill and planting at the upper level. This shelter space contains the required storage space, a first aid room, cafeteria and lounge facilities.

CAUDILL
Was general architectural consultant to the participants on concepts and design of the plants.

BERNE
Oriented the architects and teams on the purpose and organization of the National Fallout Shelter program and served as general consultant on shelter policies.

EVANS
Developed detaile
climatological da
for the programs i
five geographical
locations. Advise
each architect du
ing the conferenc
of the factors of
climate that woul
influence design.

ZIMMERMAN
Acted as structural consultant to the architects on all structure exclusive of the shelters.

BACKER
Served as a consultant to the architects on a daily basis concerning the layout of the necessary electrical and mechanical services for the five factories.

ORR
Gave a one-day orientation to all the participants on the basic requirements and considerations in designing fallout shelters. Made suggestions to each architect during the development of his solution on the fulfillment of these requirements.

Director: BILL N. LACY, Associate Chairman, Department of Architecture, Rice University, Houston / Architects: FRED BASSETTI, Fred Bassetti & Co., Seattle; A. WILLIAM HAJJAR, Vincent G. Kling, Architect, Philadelphia; GEORGE T. HEERY, Heery & Heery, Atlanta; DON M. HISAKA, Don Hisaka, Architect, Cleveland; GEORGE VERNON RUSSELL, George Vernon Russell & Assoc., Los Angeles / Consultants: ROBERT BERNE, Professional Adviser, Office of Civil Defense; RICHARD MUTHER, Industrial Program Author, Richard Muther Assoc.; ARLYN A. ORR, Structural Consultant on Shelters, Oklahoma State University, Stillwater; BEN H. EVANS, Climotologist, Texas Engineering Experiment Station, College Station; KENNETH ZIMMERMAN, Structural Consultant, Walter Moore, Engineers, Houston; MORRIS BACKER, Mechanical Consultant, Bovay Engineers, Houston; WILLIAM W. CAUDILL, Architectural Consultant, Caudill, Rowlett & Scott, Houston / Special Credits: Coryl LaRue Jones, Department of Architecture, Rice University, Houston; Dimitri Demopulos, Dimitri Demopulos, Architect, Houston; Laurie Olin, Fred Bassetti & Co., Seattle; Edward Wundram, Heery & Heery, Atlanta; Charles Lawrence, Frank Lawyer, Jack Yardley, Caudill, Rowlett & Scott, Houston.

Students — Rice University: Michael S. Adams, Stephen A. Brown, Salvatore Commarata, Margaret W. Christoffer, Stephen B. Engberg, P. Monte Frost, Frederick Gardner, Jerry B. Jones, Frank S. Kelly, Stephen B. Haines, Jr., Ottie L. Luther, John W. Mullen, Clark D. Moore, Jawahar lal Porashar, Marcia M. Pieper, Don Ramsey, Charles F. Redman, Henry T. Winkelman, Jr., Joseph B. Vincent / University of Houston: James Martin Hagan / Oklahoma State University: E. Bert Rucker, Jerry Gibson / Texas Technological College: Kenneth D. Mauck / University of Arkansas: James Beavers, John R. Meiborg / University of Kansas: Julian M. Ominski / Louisiana State University: James Lee Thomas / Texas A&M: Raymond V. Gomez, Jr. / University of Texas: William G. Cook / Tulane University: Victor E. Stilwell, Jr.

MUTHER
Wrote the five realistic programs for the industrial plants and briefed each architect and team on the programs at their issuance.

CONCLUSION

Architecture is shelter —shelter against natural elements and enemies. Today shelter must also include protection against an invisible element — gamma rays.

The threat of devastation by nuclear force is an offspring of our technology. Most architects, engineers and laymen are only vaguely familiar with its effects. Architects of this country should be cognizant of basic considerations involved in this type of protective design, just as architects in western seaboard states must have knowledge in designing for protection against earthquakes, even though they are unsympathetic to such acts of destruction.

The general public is never shelter conscious except during an actual crisis any more than it is conscious of city planning until blight or traffic congestion becomes a threat to welfare. The building client, acting with the advice of the architects, exercises the decision whether or not his project should incorporate fallout protection, but this decision should be based on knowledge and not heresay. Since America is an industrial society, industrialists with foresight must provide not only efficient, economical plants, but means of protecting their population from nuclear attack.

To promote intelligent thinking about fallout shelters in industrial plants was the purpose of this conference and report. The ingredients of the Rice Design Fete were the experience of five talented architects who have designed countless factories, the enthusiasm of 30 willing architectural students from ten schools of architecture, the special knowledge of engineers and consultants in fallout protection design and plant operations, and a problem posed by the Office of Civil Defense, Department of Defense, to provide protection for a minimum of twice the total populations of the plants. Each architect accepted, as his first task, the fulfillment of the functional requirements of a realistic program drawn from case study factories. Recurrent themes of concern appear in each of the solutions for the factories and shelters.

First, growth is the key to success in industry. Grow or die is the premise. In most cases planned growth is possible by use of a structural module that permits easy expansion.

Second, flexibility is concomitant with growth. Change in physical requirements is anticipated by providing adaptable, uncluttered spaces. The production area of each plant utilizes long span structural systems to limit the number of columns within these spaces.

Third, cost influences the choice of materials and structural systems. The accompanying cost estimate appendix breaks down the costs for each plant and shows how each was able to stay within an imposed budget.

Fourth, landscaping is important to total plant design. In the past landscaping and attractiveness were considered too frivolous and impractical to be associated with a place of work. Hajjar's contoured landscape, the introduction of fountains, water, and courts in the others all point to the growing realization by architects of the importance of landscaping around a factory.

Fifth, the integration of structural and mechanical systems is economical because it requires less space and leaves the remaining spaces uncluttered and more attractive. Also, an orderly mechanical system can be altered or repaired more easily. Hisaka's plant is a striking example of the incorporation of concealed mechanical distribution raceways into the structure of a plant.

Sixth, each plant fits into the larger architectural scheme of the neighborhood. Hajjar insists on a residential character that blends with the surrounding houses. Russell wants an unmonumental and unpretentious building that does not impose itself on the community. All five insist on adequate space around the plants — growth space is important, but openness for harmonious and uncrowded setting is just as important.

Seventh, the dual-use space for the fallout shelter must be a natural and logical placement which is economical, safe, and psychologically pleasant. For obvious reasons of economy, it seems unwise to devote space exclusively to a function which all hope will never need to be used. Some of the architects have chosen to combine employee spaces (lounge, recreation or dining facilities) with the shelter rather than production space because the natures of their specific plants dictate cumbersome production paraphernalia which might usurp space allocated to shelter. Plant B, with portable equipment which allows easy conversion from production to shelter, utilizes its production space because the nearby services would be available during emergency occupancy. All the architects, however, have chosen spaces which are pleasant because of location and mental association during normal daily activity.

This report is not to alarm the readers unduly about the possibility of nuclear warfare, but to show how protection can be incorporated in industrial plants at minimal cost and to show that this protection can be provided unobtrusively if the architect begins with such a requirement as part of his initial program. An examination of the appendix shows the fractional amount involved for inclusion of fallout protection in the factories studied. It should be pointed out that these solutions to plant and fallout shelter design are only five of many possibilities. A greater variety would have resulted from changes in the industrial program, geographical location, or a larger number of participating architects and engineers.

Another aim in executing this research contract was to prove the feasibility of our approach to architectural research. This approach illustrates information by tangible architectural examples. We hope the designs will 1) stimulate interest in this area and 2) influence other solutions by architects and industrialists faced with similar problems. We feel that the interaction between the people assembled here was successful in producing solutions which will accomplish these goals.

I wish to express my appreciation to the architects, students, consulting engineers, and the sponsor for their efforts in making the conference a reality and a success.

Bill N. Lacy

BILL N. LACY
Director


ARCHITECTURAL COSTS FOR:	PLANT A	PLANT B
STRUCTURAL SYSTEM	$217,000.00	$183,000.00
GENERAL CONSTRUCTION	$231,000.00	$119,000.00
MECHANICAL & ELECTRICAL	$98,000.00	$78,000.00
TOTAL PLANT COST	$546,000.00	$380,000.00
PLANT COST WITHOUT FALLOUT PROVISION	$534,000.00	$366,000.00
SQUARE FOOT COST	$17.00	$12.22
SQUARE FOOT COST WITHOUT FALLOUT PROVISION	$16.63	$11.77
OVER-ALL PLANT AREA FALLOUT COST PER SQUARE FOOT	$.37	$.45
ADDITIONAL COST PER SQ. FT. OF SHELTER AREA*	$2.85	$2.86
SHELTER AREA **	4,210 sq. ft.	4,900 sq. ft.
PLANT AREA	plant and office 32,100 sq. ft. total 32,100 sq. ft.	plant and office 29,500 sq. f nursery 1,600 sq. f total 31,100 sq. f

* multiply by 10 to determine sq. ft. cost/person of fallout shelter

**divide by 10 to determine number of shelter spaces

coordinating architect, harry s. ransom / project estimator, r. c. partch
mechanical engineer, c. w. ellis / fallout and structural consultant, a. a. orr

		
PLANT C	PLANT D	PLANT E
$552,000.00	$472,000.00	$708,000.00
$185,000.00	$251,000.00	$208,000.00
$272,000.00	$165,000.00	$222,000.00
$1,009,000.00	$888,000.00	$1,138,000.00
$959,000.00	$883,000.00	$1,129,000.00
9.73	$14.20	$13.66
$9.25	$14.12	$13.55
$.48	$.08	$.11
$4.33	$.77	$1.56
11,550 sq. ft.	6,500 sq. ft.	5,770 sq. ft.
ffice 5,400 sq. ft. lant 98,300 sq. ft. otal 103,700 sq. ft.	office 15,900 sq. ft. plant 46,800 sq. ft. total 62,500 sq. ft.	plant and office 83,300 sq. ft. total 83,300 sq. ft.

The Office of Civil Defense, Department of Defense, maintains a current directory of architects and engineers qualified in fallout shelter analysis. This list may be obtained by addressing an inquiry to either the Architectural and Engineering Development Division or the Industrial Participation Office, Washington, D. C. 20301

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